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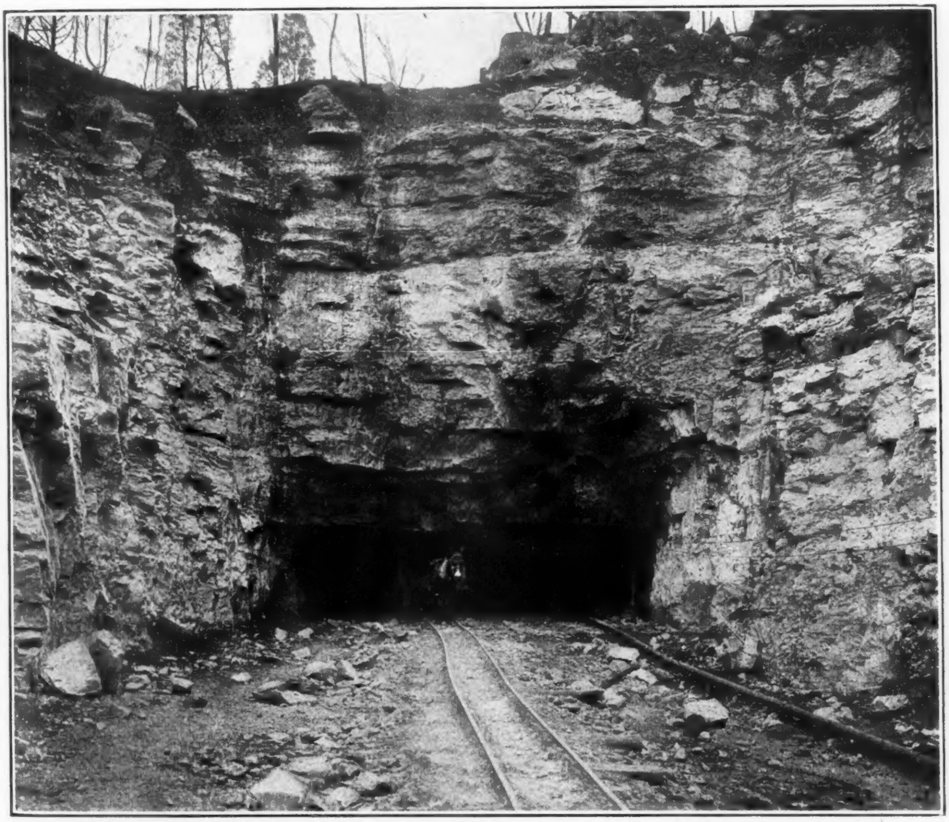

THE LOOKOUT AT LOOKOUT MOUNTAIN TUNNEL.

MINE AND TUNNEL EQUIPMENT WITH REFERENCE TO CERTAIN MINES AND TUNNELS

BY CHAS. A. HIRSCHBERG.

Time has wrought many changes in the means and methods employed in mining and tunneling projects, and it is doubtful if any but those who have watched the transitions all through really appreciate the advance that has been made towards greater speed and economy of operation.

From the crude and cumbersome devices of the early inventors there has been evolved the efficient one-man drill of to-day, such as the

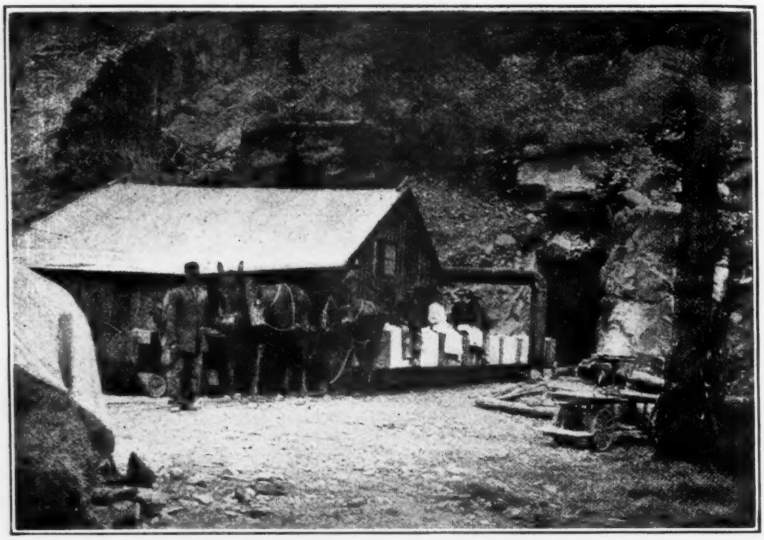

FIG. 1. LARAMIE TUNNEL PORTAL.

Butterfly, the Leyner, the Jap and the Jackhamer, tending to materially reduce the item of drilling labor, not alone in mines, but in tunnels, even where it has been found necessary to employ more than one drill in a heading, involving therefore heavier mounting equipment; as for instance, in the Laramie Tunnel, Figs. 1 and 2, where three such light drills were used on a horizontal bar the three runners being provided with two helpers in place of the usual three, as was the practice in the past with the heavier types of drills and the column mounting as seen in Fig. 3 then available. And the use of such drills in this manner has been accomplished without the sacrifice of speed; on the contrary, coupled

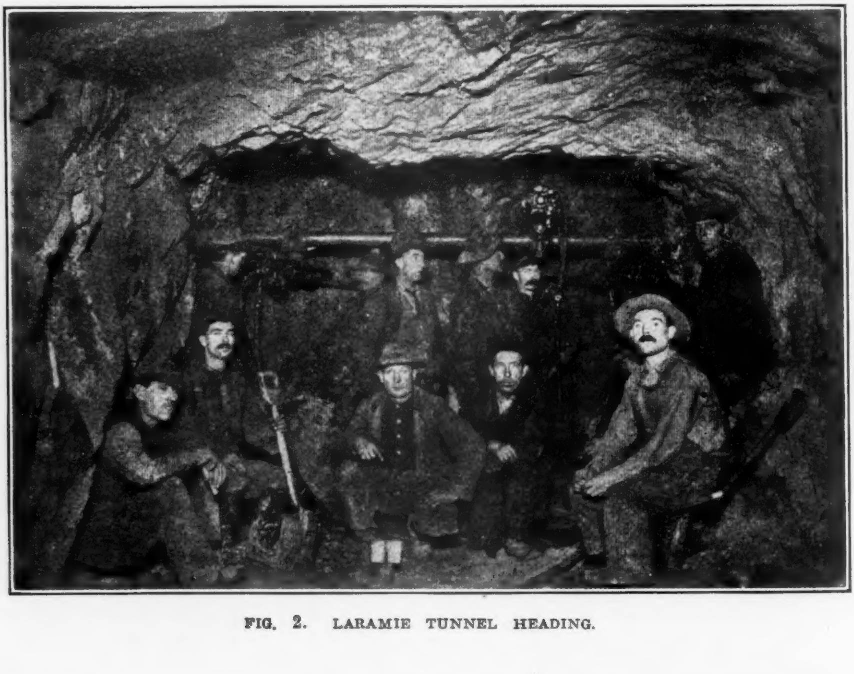

FIG. 2. LARAMIE TUNNEL HEADING.

with other advanced features of design, they have proven a material aid in increasing actual accomplishment far beyond early expectations.

In the first type of drills mentioned above some of the principles involved in early construction have been retained; in the latter a distinct departure from former design has been made. This has been accomplished by the employment of the "hammer" principle, in which the drill steel is not reciprocated but is pressed against the rock resting loosely in the chuck and is struck by a light, rapidly moving piston, as opposed to the percussive type, in which the steel is rigidly connected to the piston and reciprocates with it.

These high speed tools called for other features not necessitated in former designs, such as automatic lubrication, self rotation, etc., carrying with it the need for improvements in metals, both cast and rolled, to meet the greater strains imposed upon them. Among these may be mentioned Tungsten-Vanadium, Nickel Steel and Irco metal. A demand was also created for high speed drill steel with improved methods of sharpening. As already stated, along with these lighter, more rapidly drilling tools, times whirligig has also seen methods of mining, tunneling and quarrying greatly revolutionized. In the early days it remained a matter of necessity that only those ores running high in value be saved, while the others were cast aside to await the better methods of treatment which have since been evolved.

It is interesting to note these changes. We no longer throw aside or pass over ore that runs low in value; better methods and equipment, in both the mine and the mill, have made it profitable to utilize it.

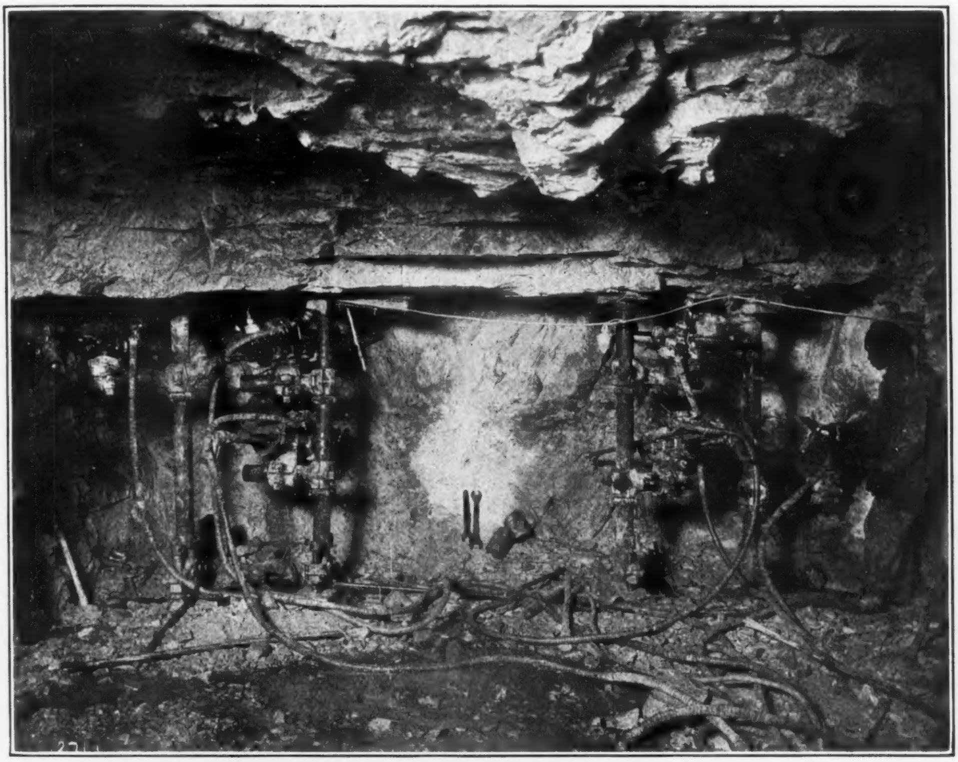

FIG. 3. HEAVY DRILLS AND COLUMNS.

In the mine we find the pneumatic feed drill supplanting the reciprocating types. This drill, used without mounting of any sort, finds its chief application in the excavation of large stopes or rooms, also in the following of narrow veins where economical excavation is entirely confined to the removal of the least amount of waste rock along with the ore.

The chief features commending this type

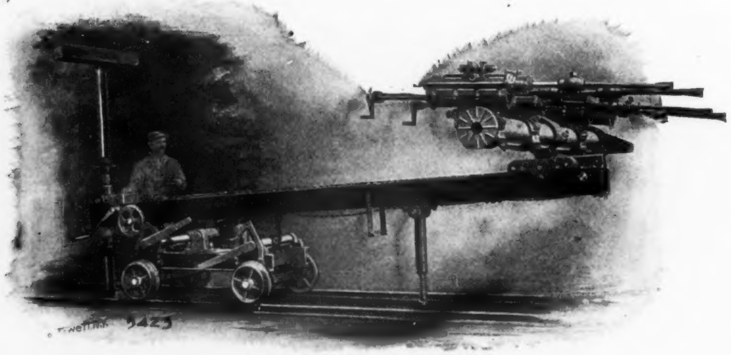

FIG. 4. TUNNEL CARRIAGE.

to the user are its ease of handling, its lightness and its rapid drilling qualities. Again we find the Jackhamer superseding mounted types of machines for shaft sinking purposes; as witness, the shaft of the Lucky Star Mining Co. in the Lake Superior region, where four of these little drills are at work in a shaft 12 feet 2 inches x 14 feet 10 inches drilling ten 6 foot holes for the sink and twenty 5 foot holes after blasting for the squaring. The progress has averaged 100 feet per month in very hard diorite. Also the Newport Mining Co., the size of shaft being 11 feet x 18 feet in the clear, the progress averaging 20 feet per week with five of these drills in hard quartzite. During February a progress of 107 feet has been reported.

The great advantage of their use in this class of work is that the drilling never stops except for the shooting, the mucking and drilling going on continuously. In addition to their lightness and ease of handling the absence of all mounting facilitates the accomplishment of more work.

As important as these changes in the drilling equipment itself, improved methods of sharpening have appeared, more attention being paid to the shape and condition of the drill bits; the problem being largely solved by the introduction of compact and efficient power machine sharpeners, such as the Leyner. Better steel heating apparatus such as specially designed oil and coke furnaces, has also made its appearance.

With the advent of power sharpeners and special furnaces came the practice of installing

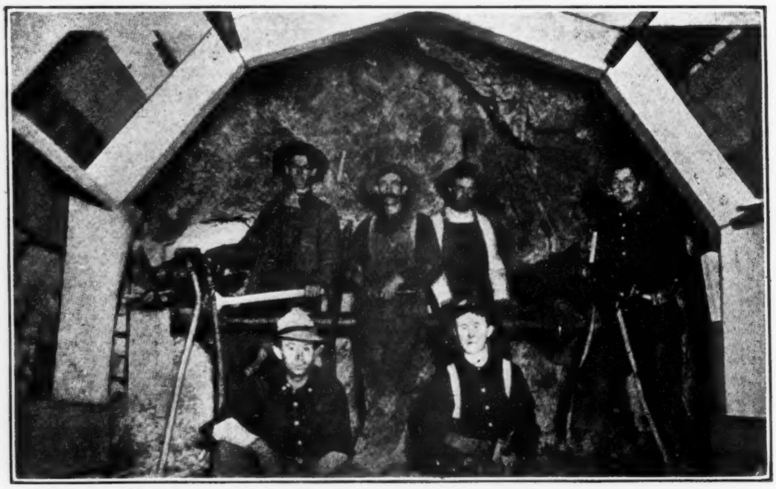

FIG. 5. ELIZABETH LAKE TUNNEL.

underground the sharpening plant, minimizing the number of steps and expense of handling large quantities of steels used by the mines of to-day with their miles of underground workings.

In tunnel driving we must not overlook the advent of the tunnel carriage (Fig. 4), as exemplified by European practice, greatly facilitating the quick set-up of a battery of heavy drills and their removal preparatory to blasting.

"With the use of these heavy drills and tunnel carriages the following records have been made:

"At the Simplon the average daily advance per heading was about 16 ft. at the Italian end and from 20 to 21 ft. at the Swiss end. This was in gneiss. In less difficult rocks an advance as high as 34 ft. in 24 hours was made.

"At Loetschberg yearly records per heading ran as high as 21 and 27.6 ft. per day, while for some the daily averages per heading were as high as 32.3 and 33.9 ft. with some beyond anything ever before achieved in tunnel driving.

"At Laramie, Mr. D. W. Brunton, in his paper presented at the San Francisco Meeting of the American Institute of Mining Engineers, in October, 1911, says:

"'From March 1st to March 8th, 1911, inclusive, the tunnel was driven in a single heading, 192 ft., a daily average of 24 ft.; but the highest rate of progress was made during the last four days of January, 1911, when the tunnel was driven 112 ft. or 28 ft. per day; the record month being March, 1911, 653 ft. being driven.'*

"The Alpine tunnels referred to were driven by the European system, and this Laramie Tunnel was driven by the American system; but the American system as used at Laramie involves a distinct departure, in that, instead of columns being used for mounting the drills, a horizontal shaft bar was used similar to that carried by the Alpine tunnel carriage, but with the distinct difference that the Laramie bar was a light, simple apparatus, only 3 in. in diameter, mounting three hammer drills, as distinguished from percussive drills."

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*From discussion of paper read before the American Society of Civil Engineers, April 17, 1912.

These lighter one-man drills permit the use of a much lighter mounting, having been the cause of the adoption, largely in the western portion of this country, of the tunnel bar mounting in preference to the usual column and arm so much in vogue with the heavier type of drills. One advantage of this practice is that mucking operations may proceed without interfering with the drilling.

A notable instance of this practice has been the work in the Elizabeth Lake Tunnel of the Los Angeles Aqueduct (see Fig. 5) where a monthly progress as high as 604 feet of 12 feet x 12 feet tunnel advance was attained. This tunnel over 29,000 feet long, was driven entirely by the tunnel bar method using modern, light and rapid drilling machines.

INCREASE IN MACHINE MINING OF COAL

The number of machines used in mining coal in 1911 was 13,819, an increase of 565 over 1910. The leading coal producing state, Pennsylvania, is also first in the total tonnage mined by the use of machines and in the total number of machines in use; but in the proportion of machine-mined coal to the total output Ohio far outranks all other states. In 1911 Pennsylvania's production of machine-mined coal was 69,131,923 net tons, or 47.76 per cent. of the total. Ohio's production of machine-mined coal was 26,556,630 net tons, or 86.33 per cent. of the total. Ohio is third in the production of machine-mined coal, though ranking fourth in the total production. West Virginia is the second state in coal production, is also second in the output of machine-mined coal, which in 1911 was 29,121,480 net tons, or 48.67 per cent. of the total. Illinois is fourth in the quantity of machine-mined coal, with 23,093,807 net tons. In addition to the lessening of the mining cost, there are two other aims to be accomplished by the use of mining machines. The undercutting of coal by hand is one of the most exacting kinds of labor, and the use of machinery materially reduces the arduous tasks of the laborer. More important than this, however, is the greater safety secured through reducing the practice, too prevalent in many mining districts, of "shooting from the solid."

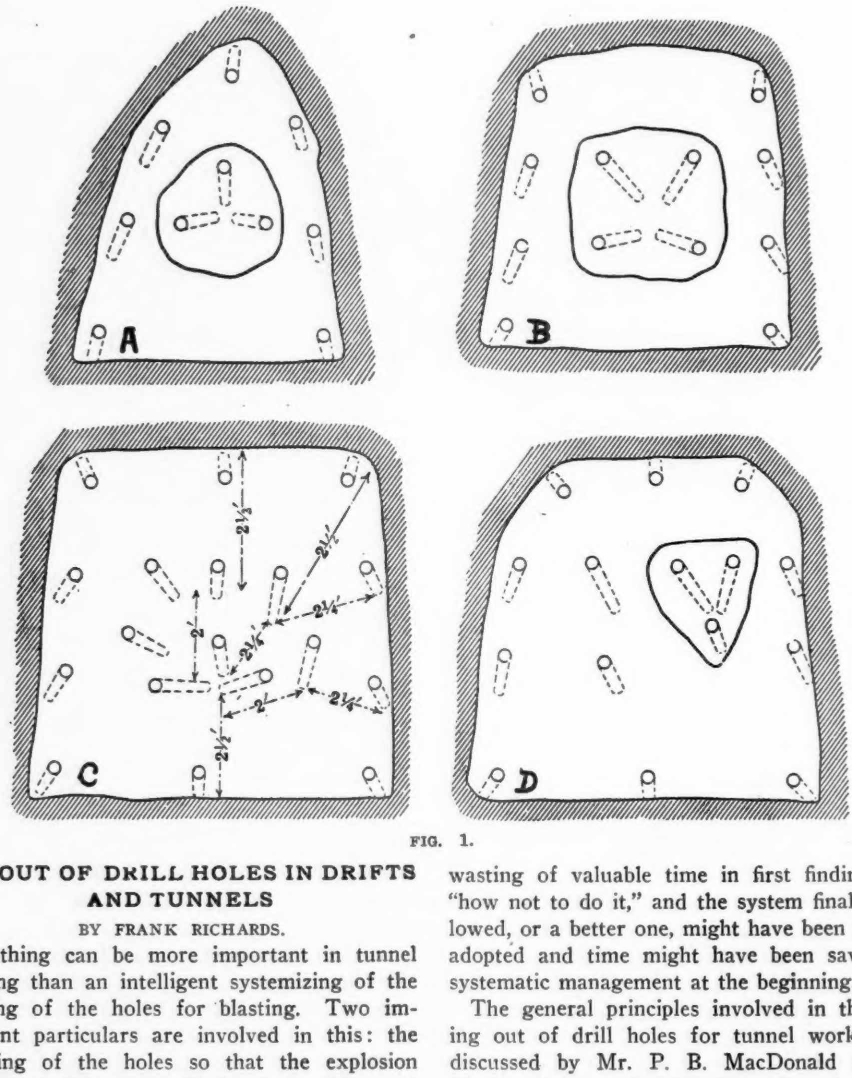


FIG. 1.

LAYOUT OF DRILL HOLES IN DRIFTS AND TUNNELS

BY FRANK RICHARDS.

Nothing can be more important in tunnel driving than an intelligent systemizing of the placing of the holes for blasting. Two important particulars are involved in this: the locating of the holes so that the explosion charges shall be most effective in breaking and dislodging the rock, and also the placing of them in such a way that the drills can be most conveniently placed and can do their work with the greatest rapidity and with as few and short delays in setting up and in making the necessary changes. Too often this matter has been left entirely to the miner and foreman, but more recently engineers and superintendents have been assuming the responsibility.

In works sufficiently protracted, as in the tunnels several miles in length, a system has gradually shaped itself, but only after the wasting of valuable time in first finding out "how not to do it," and the system finally followed, or a better one, might have been earlier adopted and time might have been saved by systematic management at the beginning.

The general principles involved in the laying out of drill holes for tunnel work were discussed by Mr. P. B. MacDonald in the *Engineering and Mining Journal,* and an abstract of a portion of his article will be good to begin with, breaking into the matter without any preliminaries.

In Fig. 1 we begin with soft rock. A shows a 10 hole cut with one back hole, frequently used in driving small drifts where it is desired to keep the back well arched. The arrangement shown in B is suited to larger square drifts. These holes would not break much hard rock because of the distance between the bottoms of the cutting-in and the squaring-up holes.

These two classes of holes determine the shape of the drift. In hard rock there are in addition what are conveniently called relief holes, because, situated and fired intermediately between the cutting-in and the squaring-up holes, they relieve the ground to be broken by the latter set.

The most important rule to be observed in placing holes is that the determining factor is not the distance apart of the starting points of the holes but the distance between their bottoms. The upper few feet break out into the drifts comparatively easily, but the inner portion breaks with more difficulty.

In planning the arrangement of holes the first consideration is to get a cutting-in hole that will break well. The smaller the number of holes used for this the better, because it is essential that cutting-in holes be fired simultaneously, and, owing to irregularities in the rate of burning of fuse, this is difficult to accomplish when a large number of holes are to be fired; also, starting a cutting-in hole is often difficult because of the angle at which the drill point has to meet the face. The excavation made by three holes meeting at a point is almost as large as by five or six, so that it is usually better to use only three or four holes for cutting-in; and, if the ground requires them, to put the extra holes in as relief holes where they will break more ground.

After deciding upon the cutting-in, the squaring-up holes are placed along the sides, bottom and top, with the ground equally divided between their bottoms. Perhaps two relief holes, one on each side of the cutting-in holes will suffice; C, Fig. 1, shows two on either side and one above, helping the middle back hole, which is important because upon its breaking depends the successful blasting of the other two back holes. In the sketch the cutting-in holes are placed low; they might have been shifted higher and the upper relief holes placed underneath. Quite a common alternative is to shift the cutting-in holes to right or left, so that relief holes are required on but one side; thus in D it is seen that the cutting-in holes are to the right and high.

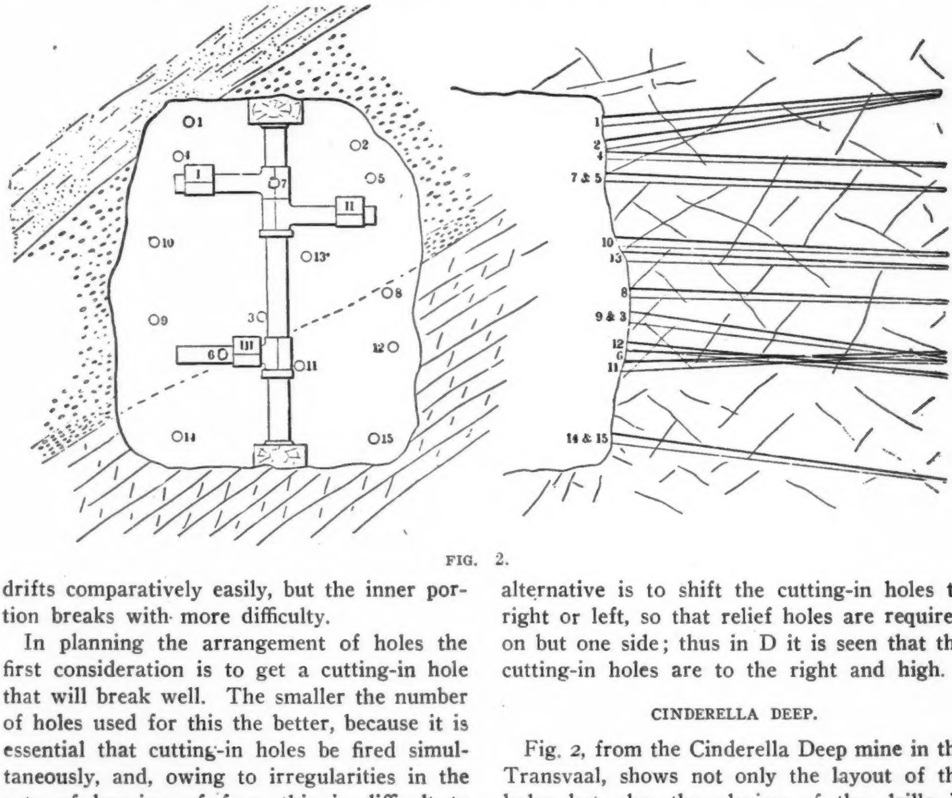


FIG. 2.

CINDERELLA DEEP.

Fig. 2, from the Cinderella Deep mine in the Transvaal, shows not only the layout of the holes but also the placing of the drills in pushing forward a 7 by 5 ft. drift at a depth of 4,000 feet. The column shown was securely set about 4 ft. from the face and all the holes were drilled by three drills mounted upon the several arms. One arm is rigged to put in a flat hole in the hanging wall, another is fixed directly below this to bore the roof hole on the other side. Safety clamps are used under these two arms and also under the lower one. No. 1 machine drills holes 1, 4, 7, 10; No. 2 drills holes 2, 5, 8, 11, 13; No. 3 drills 3, 6, 9, 12, 14, 15. Though No. 1 has only four holes

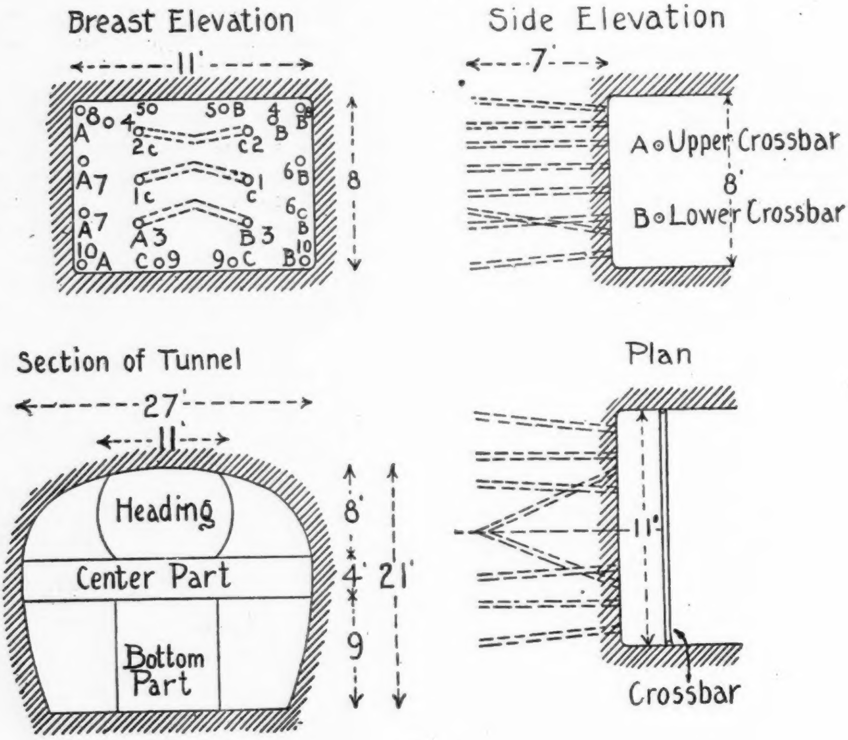


FIG. 3.

to drill, the flat hole in the hanging wall takes so long that it is not finished much before the others. No. 3 machine has all water holes to drill and should be rigged under the arm, drilling lifter holes 14 and 15 before No. 2 machine comes down to drill hole 11. No. 2 has hole 13 to drill after No. 1 has finished hole 10. If possible No. 1 is not given any more to do after it has drilled hole 10, as it is almost impossible to work with all the arms low down on the bar. No. 3 often finishes first and then it can be used to collar holes for the other machines. In the same way Nos. 1 and 2 machines can cross-collar difficult holes for each other.

MOUNT IKOMA (JAPAN) TUNNEL.

Fig. 3 shows the drilling scheme at the Mount Ikoma (Japan) tunnel. This was a double track railway tunnel 22.2 ft. wide by 19.3 feet. high, driven with a top heading 11 by 8 ft., the layout of the holes for the heading being as shown. A 5-in. horizontal bar was used with jack screws at both ends and on this were mounted three water-Leyner drills. The upper holes were drilled first and then the bar was lowered for the drilling of the others. The use of the horizontal bar facilitates the handling of the drills and the muckers can work below while the upper holes are drilled. The center or "cut" holes were drilled to a depth of 8 ft., all the other holes being 7 ft. Where the rock was hard from 22 to 26 holes were drilled in the heading, but in softer rock the number was reduced to 16 and in some cases as low as 12. The rock was granite and usually hard.

OPHELIA TUNNEL.

A typical arrangement of holes as followed in driving Ophelia tunnel in the Cripple Creek District of Colorado is given in Fig. 4. This was a drainage tunnel 9 by 9 ft. in the clear, with some portions 10 by 12 ft. Holes 1 and 2 were drilled downward with their inner ends nearly meeting. The fuse for these holes was so cut that they were fired first and nearly together. Holes 3 and 4 are cut holes, drilled looking up and about the same depth as 1 and 2. Their inner ends did not approach each other, and these were fired just after 1 and 2. Holes 5 and 6 were the back cut holes, drilled

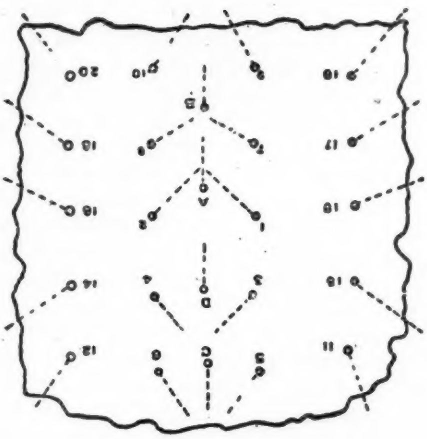


FIG. 4.

looking up but not extending above the top of the tunnel. These were shot together and just after 3 and 4. Cut holes 7 and 8 looked down and were timed to shoot after 5 and 6. The cut lifters 9 and 10 looked down and extended below the proposed bottom of the tunnel. The back rib holes 11 and 12, also rib holes 13 and 14 looked up, while 15 and 16, also 17 and 18 rib holes, and rib lifters 19 and 20 all looked down, all extended beyond the line of the side walls and all were shot at the same time. Where stiff ground was encountered holes A and B were put in and shot with 1 and 2 and with 7 and 8 respectively. Where very stiff ground was found holes C and D were added and shot with holes 3 and 4 and with 5 and 6 respectively.

HOT TIME, NEWHOUSE TUNNEL.

Fig. 5 is from the Hot Time lateral of the Newhouse tunnel, Idaho Springs, Colorado. The bore was 5x7½ ft. in the clear driven through granite, gneiss and schist, very hard to drill and so tough and tenacious that it broke badly. There were, however, no soft seams nor any defined walls to follow, there was no timbering to be done, the ground was not wet enough to require rubber coats, and record progress was made. A horizontal bar was used with a Model 6 Water Leyner drill. The machine man and helper set up the drill without waiting for the dirt from the previous shots to be cleared up. The first set-up of the bar was high enough and far enough from the face to allow holes 1, 2 and 3 to be started close to the back and to be drilled with very little rise in their depth of six feet. From the first set-up of the bar at position A, all the holes except the three bottom ones, or lifters, were drilled. Holes 1, 2, 3, 4, 5 and 6 were drilled with the machine above the bar, to which it was attached directly, without any arm. When these holes were finished the drill was swung under the bar and all the others except the three lifters were drilled. By the time these twelve holes were drilled the muckers had cleaned up the face. Then the bar

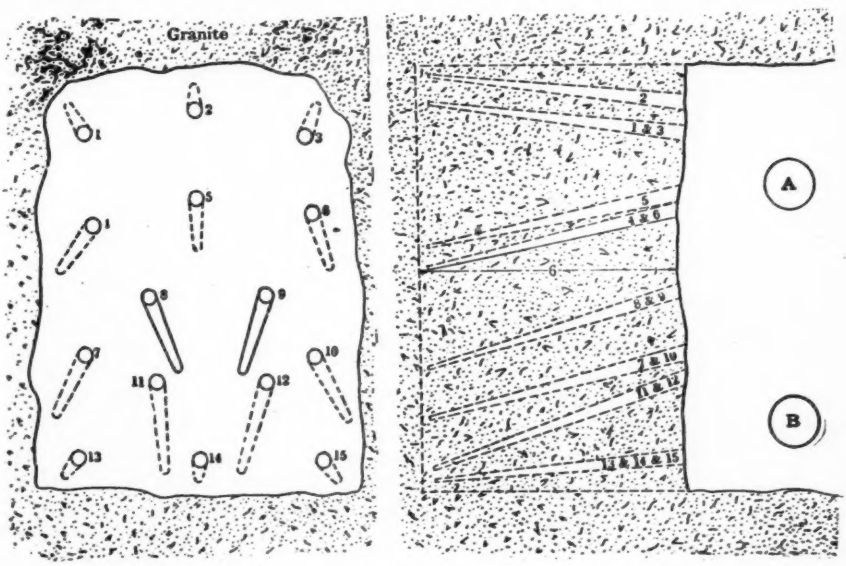


FIG. 5.

FIG. 6.

was torn down and set up in position B, close to the bottom. The usual round was 15 holes as here shown, each 6 ft. or more deep, bottoming at 1½ in. diameter.

SOUTHWEST LAKE AND LAND TUNNEL.

Fig. 6 is from the Southwest Lake and Land tunnel driven through tough limestone out under the lake at Chicago. The general size of the tunnel is about 16 feet both vertically and horizontally, the heading taking the upper half of the section. Four Ingersoll-Rand drills mounted on two columns were used. There are eight center cut holes with four helpers on each side, while to force the remnant twelve rim holes are drilled around the outside. The bench is removed with eight vertical holes, no lifters being used.

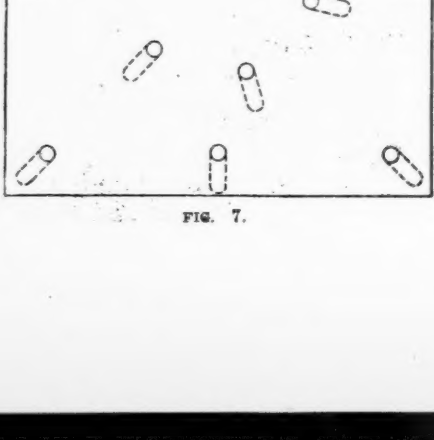


FIG. 7.

NOWATA LEAD AND ZINC COMPANY, SHAFT UPRAISE.

Fig. 7 shows the plan of holes used in upraising a shaft on the property of the Nowata Lead and Zinc Company, Duenweg, Mo. There was a 6-in. hole from the surface which had been drilled for another purpose and a cable was led down through this from a hoisting engine above, the cable sustaining a platform which carried the drills, the holes, of course, being drilled upward. There were 14 holes driven up 5 feet for each round. Six of these corresponded to the ordinary sump holes when sinking a shaft and the others were the cut holes. When ready to blast the platform was lowered, unhooked from the cable and hauled to one side in the drift of the mine, while the cable was hoisted out of the way.

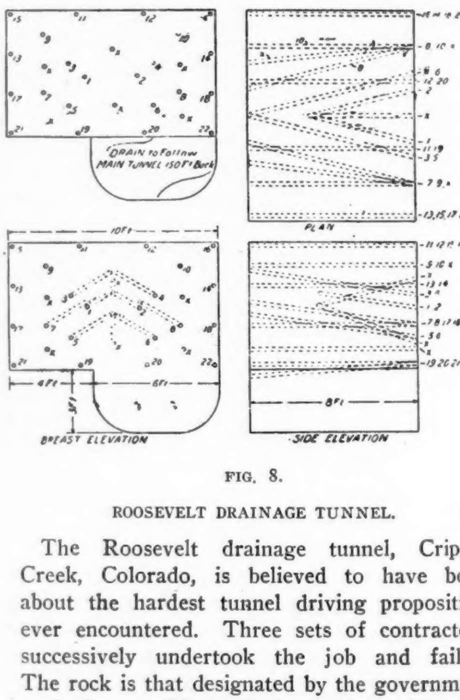


FIG. 8.

ROOSEVELT DRAINAGE TUNNEL.

The Roosevelt drainage tunnel, Cripple Creek, Colorado, is believed to have been about the hardest tunnel driving proposition ever encountered. Three sets of contractors successively undertook the job and failed. The rock is that designated by the government geologists as Pike's Peak granite. Most of it is composed mainly of coarse grains of reddish feldspar, a small amount of quartz, and is usually deficient in hornblend and other dark colored constituents. In some parts the rock has a gneissic or schistose structure, but in the main it is characterized and made notorious by the lack of seams or joints. Thus while the rock itself is hard, the lack of lines

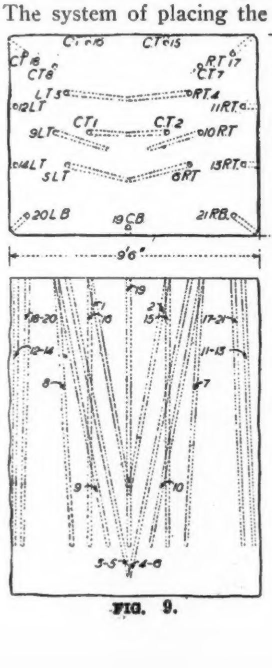
of fracture and planes of seaming is doubtless responsible for the poor rate of progress made by the first contractors. The tunnel was started 10 feet high and 7 feet wide, but in the final contract this was changed to 10 feet wide by 6 feet high over the rails and a 3 by 6 ft. drainage ditch was added.

After the trial of several systems of placing the drill holes, that shown in Fig 8 was finally proved the best adapted to the tough nature of the jointless rock. No. 6 water-Leyner drills were employed, these being later supplanted by No. 9 heavy duty drills. In attacking the ordinary rock all holes were drilled 8 feet, except the cuts and relief cuts, Nos. 1 to 8, inclusive, which were drilled to a 10-foot depth. In extra tough ground, these lengths were each cut down 2 feet and in addition to the 22 holes used on the ordinary rock and numbered in Fig. 8, the six extra holes "X" were put in. In the good breaking ground encountered in the month of January, however, the cut holes were drilled 11 feet, and all others 9 feet deep.

At first, even with the use of from 300 to 350 pounds of 60-per-cent. dynamite, great difficulty was experienced in properly blasting the eight cut holes, sometimes several loadings of them being necessary to blow out the cut. After finally putting in the two extra cuts shown, however, even the toughest ground yielded. The system of placing the holes was evolved, not only with a view of best blasting the tough rock, but also to allow of the greatest economy of time in drilling. These ends proved to be best effected by mounting the two Leyner drills on a single horizontal cross-bar edged against the sides of the bore, instead of on the usual two independent vertical columns. In this way even the maximum number of 28 holes required but two set-ups of the bar. It will be readily understood that this way of placing the bar eliminates the necessity of mucking out to the bottom before starting drilling, as when vertical columns are used.

The grade line is carried about 18 inches below the top of the bore and about 8 to 12 inches below this is placed the bar. From this, the center and corner back holes are drilled, and then by revolving the drill around and beneath the supporting bar, all of the remaining holes except the center lifters and bottom corners are put in.

It will be understood that the difference in the level of the drill bit between its position on top of the bar, and below the bar, amounts to about 2 feet. By using proper judgment in placing the horizontal bar, therefore, the feat of putting in 18 holes from one set-up is easily accomplished. The cross-bar is then shifted to its second position, usually about 18 to 24 inches above the floor, and the last four holes put in. In tough ground an extra center cut hole "X" is also put in from this set-up.



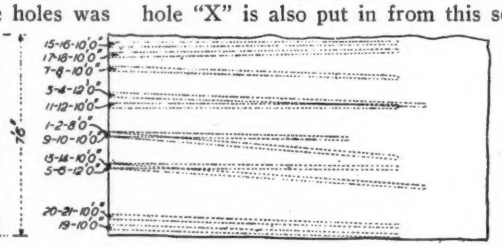


FIG. 9.

The bits used at the start of a hole are 3 feet in length and have a diameter of 2¾ inches. Each succeeding steel is 2 feet longer than the one before, the 11-foot cut holes requiring 6 steels to a hole, while the others require 5 steels each. The diameter of the hole bottom averages about 1½ inches.

The number of steels have been carefully determined so that as fast as one becomes dulled, it is replaced by a sharp one. While this may seem a minor point, experience in the last 5 months has proved it a potent factor in influencing the speed of drilling, and increas-

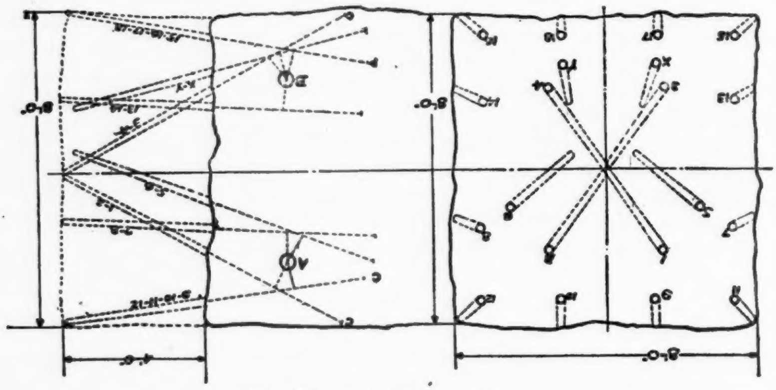


FIG. 10. THE LEYNER CUT.

ing the rate of progress made in driving the tunnel.

The ditch was kept back of the breast about 150 feet and taken out at convenient intervals by placing vertical 3-foot holes spaced on 2-foot centers along the intended center line of the ditch, an ordinary tripod being employed for this work.

LARAMIE-POUDRE TUNNEL.

The Laramie-Paudre tunnel in the beginning of the year 1911 held the two best American tunnel driving records: 609 feet in January, 1911, and 653 feet in March. Fig. 9 shows the layout of the holes in regular work. The holes were drilled and shot in the succession as numbered in the cut, requiring two set-ups of the tunnel bar (no column being used). The upper set-up is drilled on top of the muck pile and in the meantime the muck is cleared away, when the bar is lowered and the lifters put in. Holes are started $2\frac{1}{8}$ inches in diameter and bottomed $1\frac{3}{8}$ inches.

Two No. 8 Water Leyner drills are used drilling 10 ft. and 12 ft. holes. In case of extremely hard rock a third machine was mounted, each machine drilling holes as follows:

Holes lettered LT are drilled by the left-hand machine on the top set-up, those marked CT by the center machine on the top set-up, and those marked RT by right-hand machine on the top set-up. The bar is then lowered and each machine puts in a lifter, lettered, LB, CB, and RB.

The blasting charge for a round generally consists of about 100 sticks of 100 per cent. gelatin, 150 sticks of 60 per cent., and 250 sticks of 50 per cent.

THE LEYNER CUT.

It is proper in this connection to call attention to what has been designated as the "Leyner Cut." This is a systematic arrangement of holes which takes into account the placing of the holes so that they will be most effective in shattering and displacing the rock and also considers the convenience of the driller and the best possibilities of the drill. The objects attained by the use of the Leyner Cut are the drilling of the holes with as few changes of machines and set-ups as possible and pulling first a pyramid shaped wedge of rock from the center, after which the rest of the round breaks readily. It is particularly suitable for solid formations containing no slips or seams to break to and has been used with marked success particularly in the hard bodies of rock and ore in Northern Michigan, resulting in at least one case in drifting at nearly four times the speed made formerly with reciprocating machines. Referring to Fig. 10, C shows where the crank comes back to in each case. A is the cross bar in first position. From the top of the bar the four back holes 9, 10, 11 and 12 are drilled. The machine is then "dumped" or tipped forward until the crank can just turn and clear the back or top of the drift. It is then moved out a little on the bar and the top center cut holes 1 and 2 are drilled. If the bar is set up correctly in a drift of the size here sketched the machine can be "dumped" enough to reach the center of the drift heading with the bottom of the hole. The machines are then turned under the bar and side holes 7 and 8 and cut holes 5 and 6 are drilled. The bar is then changed to position B, the machines are set up on top and

side holes 13 and 14 are drilled. Then after turning the machines under the bar, they are tipped up in front so that the crank just clears the bottom of the drift and holes 3 and 4 are drilled to about meet holes 1 and 2 in the center of the heading. The four lifters 15, 16, 17 and 18 are then drilled and if there is time enough relievers, as X and Y, may be drilled to make sure, but if sufficiently strong explosive is used the round will break without them. This round has increased the amount of development work accomplished wherever it has been used, and there are two reasons why it is practically impossible with piston drills. They are unable to drill fast enough, particularly on account of the dry holes, and the size of the piston drill is too great to permit the putting of it in the positions necessary to give the holes the proper pitch and angle.

DRIVING A LONG ADIT AT BONANZA COLO.

BY WILL C. RUSSELL.*

The Rawley Mining Co., operating at Bonanza, Saguache County, Colo., has completed its new 6,235-ft. development and drainage tunnel, having cut the main lode 1,200 ft. from the surface and at a point 600 ft. perpendicularly below the lowest former workings, exposing a 6-ft. vein of heavy iron-sulphide ore, carrying silver and copper, together with a small percentage of lead and zinc and a little gold.

UNDERGROUND CONDITIONS.

The work of driving this tunnel, which is 7x8 ft. in the clear, running principally through altered andesite and at about a right angle to the vein system, covered a period of 17 months and 12 days. The rock varied greatly in hardness and friability, it having been necessary to timber a total of 1,618 ft. As an indication of the irregularity of the formation, it may be said that in April, 1912, only 40 ft., were driven, while in August, 1912, the adit was advanced 555 ft. in 26 days of drilling, the remainder of the month having been given up to timbering.

Considerable water was encountered at various points, a maximum flow of 1,500 gal. per min. having been struck in December, 1911, which finally decreased to about 1,000 gal. per min., which latter amount is now issuing from the portal. One of the chief reasons for running the tunnel was the draining of the upper workings of the company, which have a total length of 7,416 ft., and about one-half of which are in commercial ore. Upon cutting the vein at the 1,200-ft. level, the upper workings began to drain at once, and in 38 days thereafter they were completely unwatered.

The tapping of the vein at the tunnel level immediately put in sight an additional, large tonnage of ore, the shoot on the third level, where the greatest amount of drifting has been done, being 840 ft. in length. No ore has been stoped or shipped from the mine for seven years, it having been the policy of the company to develop a tonnage of sufficient magnitude to justify handling the property on a large scale. From the surface to the 1,200-ft. level, the ore has changed considerably in character, i. e., from a silver-lead-zinc ore above, to a silver-copper ore below. Certain portions of the ore can be shipped as mined, others may be sorted and shipped, while still others should be milled. The company has on the property a 100-ton concentrating mill, which was erected for experimental purposes.

EQUIPMENT USED.

In the work of constructing the new tunnel, there were consumed 41 tons of 16-lb. rails, 38 tons 241 lb. of powder, 33,819 caps, 51 miles of fuse, and a little over 2,000 cords of wood. A steam plant of 120 hp. capacity and an Imperial type 10 Rand compressor furnished the power, while the workings were ventilated by a No. 3 Roots suction blower, directly connected with a 9x9-in. high-speed, upright engine.

Slip-joint pipe, 12 and 13 in. in diameter, of No. 18 iron, riveted and dipped, was used in connection with the blower, while the compressed-air pipe ran from a maximum of 6 in. down to 3 in. in diameter at the heading. Three air receivers, 42 in. in diameter by 10 ft. in length, were placed at intervals of about 2,000 ft. in the tunnel. In the blacksmith shop there were used a No. 8 Bradley coke furnace for heating the drill steel and a No. 2 Leyner pneumatic sharpener, drop hammer, etc. For the purposes of the tunnel construction alone a camp of 14 buildings was erected. A total of 40 all-steel cars of 17⅓ cu. ft. capacity each, and six animals were used for hauling the muck. The normal crew in the heading consisted of a shift boss, two machine men, two machine helpers, three muckers, two trammers and a pipe-and-track man.

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ROUTINE OF WORK.

Two machine drills of the No. 8 water Leyner type, carrying 1¼-in. hollow steel, were used on each shift and were mounted on a 7-ft. cross-bar for the top set-up and on an 8-ft. bar for the bottom set-up. Three hangers set into hitches in the ribs at the roof, held the air and water hose in the clear. No. 44 square-pointed shovels were used to remove the muck from heavy steel plates, which covered the floor from rib to rib and extended 30 ft. from the face.

At the beginning of the operation two shifts, drilling 7- and 8-ft. rounds were maintained, but later on it was found that three shifts drilling shorter rounds produced better average results. During the operation of removing the muck, the machine men drilled the top, and in ordinary ground the muck was removed by the time the machine men were ready for the lifters. According to the requirements of the ground, 8x8-in. and 10x12-in. timbers were installed, mud sills being laid wherever full tunnel sets became necessary. Most of the timbers were peeled and hewed, these being considered superior to sawed material.

A ditch 1 ft. in depth and 2 ft. in width, dug along the right rib and under the mud sills, carried off the water. The ventilation, compressed-air and machine-water pipes were set on cross ties over the ditch, while the track was placed on the opposite side of the tunnel. A grade of 6 in. to 100 ft. was adopted, all the timbers being lined and graded with instruments.

In the operation of driving, hangers suspended from plugs in the roof were used to give the center line, and the grade of the back. At every survey station the grade was taken and corrected, and upon completion of the 6,235 ft. a check leveling showed the breast to be a little over a foot above schedule, this rise having been due to the difficulty in laying sills in flooded and running ground. After considerable experimenting it was found that 40 per cent. dynamite was the most efficient explosive day in and day out. The entire cost of the adit was $123,920, or $19.87 per ft. During the operation, John Allen Davis, engineer of the U. S. Bureau of Mines, spent 10 days on the property gathering data which is to be published in one of the forthcoming Government reports.

Messrs. Simonds & Burns, of New York, consulting engineers of the Rawley company, planned the work, while the local operators were in charge of Will C. Russell, manager, and Charles E. Beckwith, engineer.—*Engineering and Mining Journal.*

SHALLOW HOLES VERSUS DEEP HOLES

The driving of the Rawley tunnel, treated of in the preceding article, was described in greater detail in a paper by Mr. F. M. Simonds and Mr. E. Z. Burns presented at the New York meeting of the American Institute of Mining Engineers. The following is, in part, the contribution to the discussion of this paper by Mr. W. L. Saunders:

The dimensions of this tunnel are 7 feet high by 8 feet wide with a length of a little over 6,000 feet, a typical mining tunnel, a little over one mile long, and of familiar dimensions. The best monthly progress, 8 to 12 ft. rounds, is 414 feet, and the best monthly progress for the shallow rounds 4½ to 5½ feet amounted to 555 feet. I want to call particular attention to the statement that when they changed from a double shift to a triple shift, putting in shallow holes, that they got better progress. The shallow hole idea is the European idea, it is the Alpine Tunnel idea, it is the idea by which engineers have carried through those great enterprises of piercing the Alps, in the case of the Simplon Tunnel and the Arlberg and the Loetschberg Tunnel.. These recent Alpine tunnels have all been driven on the shallow hole plan, in other words, they put in a hole about a meter or a little more than a meter in depth, and of rather large diameter, as compared with the American system, which is a hole as large as you can reasonably get it; and that means that by the time it is in to the bottom, say 10, 12 or 14 feet, it is just a little larger than the diameter of the steel, the result being that you are putting the explosive at the bottom in a section of hole of small diameter, which is the very reverse of what is wanted to produce the most effective results. It is much better—and this is a point I have emphasized before the Institute in papers in the past years—to put in a large number of shallow holes of large diameter and use a great deal of powder than to put in a small

number of deep holes and try to save powder and try to be very particular about the exact direction that the hole must take. The European system simply peppers the head with holes, and they get better results by doing it.

The total cost per foot of advance in completed tunnel is $19.87. That is a very fair figure, and less than the estimated cost made before this tunnel was driven. The average total cost per cubic yard excavated is $7.64. That may seem high to some of us, but if you go over the figures of labor cost in this paper you will see that the wages are higher. The people employed on this work have evidently been compelled to pay a maximum rate of wages for this class of work, and taking that into consideration the figures are not high. The average number of feet of hole per drill per drill hour was 12.2. The approximate yardage per foot of advance, allowing for 25 per cent. over-breakage and swelling, was 2.6 yards, or a cost of $7.64 per cubic yard. In all of this we must take into consideration the difficult rock which was encountered and the water troubles which they had; yet, to compare the progress of this tunnel with that of any of the recent tunnel records which we have, the progress appears to be very favorable.

The most recent of these figures was made at the Arizona Copper Company's mines at Morenci, Arizona, the tunnel being 8 by 9 feet, where 780 feet advance was made in twenty-nine days, employing two C-110 drills mounted upon a cross-bar. We also have the record of the Laramie Tunnel, in Colorado, which was similar to this except that it had a ragged section, which fact enabled them to make greater progress. In the Laramie Tunnel the progress was in excess of the progress given in this paper.

Now, the description of the process of driving tells us that this tunnel was driven by the system of mounting a horizontal cross-bar across the tunnel. Here we have a thoroughly modern system, the same, by the way, as was used at the Laramie Tunnel. In the American system of tunnel driving vertical columns with arms on them are usually employed. The European system employs horizontal bars mounted on carriages. The system described in this paper is neither one nor the other; they use a horizontal bar without any carriage; in other words, they have adopted the Alpine system of tunnel driving, but they do away with the carriage. The piston drill is a machine which reciprocates and which creates a great deal of shock on its mounting, necessitating a very heavy bar or column. The machine itself is heavy, and using it in that way they must either adopt the carriage system or the vertical column with arms.

Those who drove this tunnel used the hammer drill, which is lighter in weight and does not give the jarring and reciprocation, hence they are able to use a light bar which a few men in the heading can handle to advantage. This light bar is carried on top of the muck pile after the blast and jacked in place at a distance close to the roof, the drills are put on and put in operation, the men work the drills standing on top of the muck, the muckers being at work at the same time in digging away the muck underneath them. By the time they get this muck removed to a considerable extent the drillers are about ready to let the bar down, and just about that time the muck has been taken away, so that if necessary it can be placed at a lower position in order to put in the lower round of holes if these cannot be drilled from a single setting of the cross-bar. By such a system as this they have been able to make a progress, I believe, of twenty-six feet per day, in other words, a little more than one foot an hour during all of the twenty-four hours in the day. That, of course, is not the record. The Alpine system has made about 30 feet per day, and in the Laramie Tunnel they have made something like 24 feet a day. Comparing progress of this character, however, we must always take the rock into consideration, also the length of the tunnel. The Alpine tunnels are longer tunnels, and they were able, by adopting a certain system and carrying it out for a long period of time, to get the efficiency of the workers very high.

The engineers in this tunnel decided that better results could be obtained by operating three shifts per day to drill shallow holes. This plan was put into effect December, 1911, and it proved to be very efficient. In calculating the results as given in the table printed in the paper, it shows that the average number of feet of hole per drill per drilling hour was 12.2 feet. This is good, but not remarkable, as it involves only approximately 2.5 inches per minute. Of course, the rock conditions govern this.

COMPRESSED AIR TROUBLE IN AN ENGLISH MINE

BY FRANK RICHARDS.

I wish to call the reader's attention to the essential portions of an interesting letter recently received from the manager of a large English coal mine. The writer says:

"We have at this colliery a large compressed-air installation. The compressor consists of a cross-compound condensing steam engine and a two-stage air compressor with a capacity of 9,000 cu. ft. of free air per minute. We have about 13 miles of pipe, which comprises two mains, each 4 miles long; two mains, each 2 miles long; and various lengths of tappings, making a total of about 13 miles.

"The air pressure, at the compressor, situated on the surface, is 52 lb. gage, while at the two ends of the 4-mile mains (especially in the winter time, or in cold weather), the pressure varies from 10 to 14 lb. gage, which shows a loss of from 73 to 80 per cent. As the entire colliery depends on compressed air for driving the hauling engines and pumps (not coal cutters), this great loss is an important item. If you can suggest a way to reduce this loss of power it will be welcome information.

"The shaft is 1,690 ft. deep. Would covering the pipes leading down the shaft, with some nonconducting material, such as boiler covering, be of any use? The temperature of the air leaving the compressor is 250 deg. and at the shaft bottom it is only 90 deg. F."

In answer to the question asked in this letter, allow me to say nothing could be gained by covering the pipes. When air is transmitted to such distances, it invariably attains, more or less closely, the temperature of the surroundings. This is quite plainly the case here where the temperature of the air, in going only a third of a mile or so down the shaft, has fallen 160 deg. F.

It would seem, at once, that this is a case of too low initial pressure, very common in English mining practice, and an insufficient pipe capacity. It is much to be regretted that no information is given regarding the size of the pipes, which is a most important particular.

In the absence of any statement to the contrary, we may assume, at first, that the pipes are without leakage, which may or may not be the case. Air pipes with proper attention are less likely to leak than steam pipes; but often they do leak more, because the air leak does not sizzle and drip and compel attention, as do steam leaks. That air-pipe lines may be made tight is attested by the many long pipe lines in use and kept at full pressure in switch and signal service; and by the many-jointed and valved air-brake pipes, in service on trains.

We would, in the present case, shut off everything, at the extremities of the lines or wherever the air is used; and pump up to maximum pressure, at the compressor; and observe how this pressure holds. If the pressure continuously drops there are, of course, leaks and these must be found and stopped. If the pipe is properly laid at first, there should be no leaks and none are likely to develop later. But leaks, however, small, will grow bigger and become more and more difficult to stop. It is unfortunate for anyone who has to do with compressed air to assume that leaks are a legitimate part of the game. On the contrary, they show a poor installation.

PIPE CAPACITIES.

The Johnson formula for the flow of air in pipes, which is quite generally used, is with a slight change of the constant, as follows:

$$p_1^2 - p_2^2 = \frac{V^2 l}{2000\ d^5} \qquad \text{(A)}$$

Here, V is the volume of free air, in cubic feet per minute; l is the length of pipe, in feet; d the diameter of the pipe, in inches; p_1 the initial absolute pressure (gage pressure + 14.7, for sea level); and p_2 terminal absolute pressure.

The formula (A) may be transformed as follows, according to the purpose for which it may be used:

$$l = \frac{2000\ d^5\ (p_1^2 - p_2^2)}{V^2} \qquad \text{(B)}$$

$$V = \sqrt{\frac{2000\ d^5\ (p_1^2 - p_2^2)}{l}} \qquad \text{(C)}$$

$$d = \sqrt[5]{\frac{V^2 l}{2000\ (p_1^2 - p_2^2)}} \qquad \text{(D)}$$

In the case before us, the absolute pressure, at the compressor, is 52 + 14.7 = 66.7 lb. per sq. in.; and the pressure at the end is, say 14 + 14.7 = 28.7 lb. per sq. in., the difference or drop being 66.7 — 28.7 = 38 lb. This terminal pressure, by the way, is 43 per cent. of the initial pressure, and the percentage of pres-

sure "loss" is only 57, instead of 80 per cent., as stated.

We are told that there are two 4-mile lines; and we may assume that each transmits about one-half of the air, so as to enable us to estimate the possible conditions. Say, then, that we have a 9-in. pipe (which we are aware is not a common commercial size), 4 miles long, transmitting, say 4,500 cu. ft. of free air per minute, at the initial pressure of 66.7 lb. absolute.

By formula *A*, we have,

$$p^2_1 - p^2_2 = \frac{4500^2 \times 4 \times 5280}{2000 \times 9^5} = 3621$$

which gives the difference between the squares of the initial and terminal absolute pressures. But, $66.7^2 = 4449$, and $4449 - 3621 = 828$; and $\sqrt{828} = 28.7$, which is, therefore, the terminal absolute pressure. This shows a drop of $66.7 - 28.7 = 38$ lb.

Noting the above result, obtained from formula *A*, taking the initial pressure at 52 lb. gage; let us now assume that the initial pressure was, say 100 lb. gage, or $100 + 14.7 = 114.7$ absolute; and observe the difference. Now. since $114.7^2 = 13{,}156$, we have $13{,}156 - 3621 = 9535$; and $\sqrt{9535} = 97.65$, which is then the terminal absolute pressure. The pressure drop in this case is $114.7 - 97.65 =$ say 17 lb.

This shows clearly what an increase of initial pressure will do toward reducing the pressure drop, in transmission. Without giving further figures, it may be stated that if, in the last case, the pipe had been 10 instead of 9 in. in diameter, the theoretical terminal absolute pressure would have been 105 instead of 97.65 lb., and the drop would then be only $114.7 - 105 = 9.7$ lb. Thus, by adopting a suitable diameter of pipe the pressure drop, in transmission, may be whatever we choose.

RELATIVE CAPACITIES OF SMALL PIPES

In many installations where the *mains* are of sufficient size, there is still a considerable final drop of pressure in branches and extensions that are too small. It is not sufficient to have the sum of the sectional areas of the smaller pipes equal to that of the main pipe that supplies them. The pipe areas are, of course, directly as the squares of the diameters. For example, a 2-in. pipe has one-fourth the area of a 4-in. pipe; but, for the same pressure drop, four 2-in. pipes, though having the same total area, will transmit much less air than the single 4-in. pipe, because of the greater rubbing surface of the former. If the four 2-in. pipes were required to transmit the same quantity of air, per unit of time, the pressure drop would have to be much greater.

It has been found, in practice, that the square root of the fifth power of the diameter approximates the relation of pipe capacities for delivering air. For example, as stated previously, a pipe of one-half the diameter of another has only one-fourth the area of the larger pipe; but it will not transmit one-fourth as much air, under the same pressure drop. For the same pressure drop, the ratio of air volume, in this case, will be

$$\frac{V_1}{V_2} = \sqrt{\left(\frac{1}{2}\right)^5} = \sqrt{\frac{1}{32}} = \sqrt{0.03125} = 0.176$$

Then, to transmit the same volume of free air, under the same drop of pressure, will require $\frac{1}{0.176} = 5.65$ of the smaller pipes. Or, say a pipe of twice the diameter of another will transmit 5.65 times the volume of air, with the same pressure drop, for any given distance and initial pressure. This difference becomes greater as the difference in pipe diameters increase. A pipe of only one-fourth the diameter of another will transmit not $^1/_{16}$, but $\sqrt{\left(\frac{1}{4}\right)^5} = {}^1/_{32}$ of the air volume, for the same initial pressure, pressure drop and distance.

AIR SAVED BY PRESSURE LOSS.

It must not be supposed, however, that this drop of pressure, in transmission, always, means a loss of power. That will depend on the way in which the air is used in doing its work, after transmission. There might be cases where the pressure drop outlined in the above letter would mean a gain in actual power or a saving in air consumption, rather than the reverse; and, in that case, the loss of pressure mentioned might prove to be the most economical feature of the proposition.

The wasteful habit of the ordinary steam pump when driven by compressed air is notorious. Not only is the air used without cutoff or expansion while doing its work, and there are excessive clearances to fill; but, at the end of the stroke, the entire cylinder will fill with air at a pressure perhaps considerably

above the required working pressure, equalizing the pressure in the pipe line. The greater this excess of pipe pressure, therefore, over that required for the pump, the greater will be the loss of air.

It is always desirable to transmit air at high pressures, for the sake of pipe-line cost, if long distances are to be traversed. While the air is at a high pressure, the opportunity is presented for draining the air, so that the later freezing of exhausts may be minimized. If the air is to be used at high pressure, as usually it should be, it ought to be used expansively and reheated, if possible. The various types of rock drills now in use call for pressures approximating 100 lb. gage, in order to develop the highest efficiency in the drills.

The indications are that, in the above colliery, the pumps and the haulage apparatus mentioned would be amply supplied, so far as pressure is concerned, if a 20-lb. pressure could be maintained. If the air were to be used at that pressure but reached the work, at a pressure considerably higher; pressure reducers should be employed at that point; and after reducing the pressure, the air should be reheated as near to the work as possible. In this case, the pipe line mentioned serves as a pressure reducer; but it seems to overdo the business. It is also, to a certain extent, a reheater; as the air, notwithstanding the drop in pressure, will generally reach the point where the work is to be performed, at a temperature close to that of its surroundings.

We may say that the case in hand is a bad one and cannot be improved without redesigning and reconstructing the entire system, the cost of which would probably be prohibitive. Leaks should be sought and stopped. With two-stage compression, the delivery pressure should approximate 100 lb. gage, or, say, at least, not less than 80 lb. gage. In the present case, however, this would prove of little advantage, unless arrangements were made to use the air economically. It seems quite evident that the "loss" of pressure, in transmission, in this colliery, is only an item that is by no means the chief element of inefficiency. —*Coal Age.*

Sand for concrete is being shipped from Seattle, Washington, to Honolulu, Hawaiian Islands, as there is no suitable sand on the islands, which are of volcanic origin and surrounded by coral reefs.

THE NEW YORK WATER TUBE

BY S. W. SYMONS.

Few New Yorkers realize the magnitude of the engineering operations continually in progress within the city limits. None of them who are not in touch with the work can tell you for instance what is being done on the immense system of subways now under way in New York, and the greatest undertaking of all, the Catskill Aqueduct, which ranks in magnitude with the Panama Canal, is still less known and talked about, though indications of the work can scarcely be avoided. There are noises heard and movements felt throughout the city causing disturbance in the minds of nervous citizens, caused by the tunnel men blasting their way through the solid rock of Manhattan, three hundred feet and more below the surface.

Shaft No. 6, which is being driven by the Pittsburgh Contracting Co., is located on the southeast corner of Aqueduct and Tremont avenues, the Bronx. Ground was broken in August, 1911, electric drills beginning the job of sinking the shaft, which is 300 feet deep. Several makes of such drills were tried, but none were satisfactory, and it was found necessary to enlist the aid of several air hammer or "Jap" drills to complete the shaft without unreasonable delay, a small belt driven compressor being installed to operate them. When tunneling operations were started, in both directions from the shaft, the electric drills were abandoned and a compressing plant, consisting of two Imperial belt driven compressors of 1051 and 534 cu. ft. capacity, respectively driven by two General Electric motors, was installed, together with several "Sergeant" Rock Drills.

When only one heading is being drilled the smaller machine is shut down, when both headings are being drilled the larger machine is run continuously and the smaller is set to compensate for the fluctuations. An air receiver is placed in a horizontal position outside the compressor room, from there the air is taken to the bottom of the shaft in a 6 inch pipe, reduced to a 4 inch pipe running north and south to the two headings. 100 lbs. pressure is carried at the receiver, giving about 93 lb. at the drill manifold.

To the right of the compressing plant is the blacksmith shop equipped with two coal forges. One smith and two assistants are kept busy sharpening drill steels. Close by is a

General Electric mine hoist for hoisting the cage. Directly above the compressor plant is the shaft head, office and storeroom; from the shaft head about 100 yards of track lead across Tremont avenue to a vacant lot where a small crushing plant is erected; there the spoil is crushed and stored for future use in the concrete lining of the tunnel.

TUNNEL DRIVING METHODS

The tunnel or rather tunnels are driven on the heading and bench method; the heading, which takes up one-half of the tunnel section, being kept about 10 feet in advance. The tunnel is circular in section, roughly 18 feet in diameter, necessitating the removal of 9.42 cu. yds. of spoil for every foot of advance, or approximately 70 cu. yds. for every day's advance (7.5 ft.). This would be considerably more when considered in terms of loose material; probably 90 or 100 cu. yards.

The finished Water Tube will be lined with concrete to a thickness of one and one-half feet, reducing the diameter to 15 ft. The headings run approximately northeast and southwest, the north heading at the writer's visit was 1025 ft. and the south heading 1100 ft. from the shaft; they are expected to meet the headings from shafts 5 and 7 some time in August.

Fig 1 is a diagram of the breast, showing how the holes are placed and fired.

Fig. 2 shows the heading, which takes up approximately one-half of the completed tunnel; it will be noticed that six drills are used, mounted on three columns, two arms and two drills to each column, holes No. 1-2-3-4-11-12-13 (see diagram) are drilled from the left hand column; No. 5-14-15-16-6-17-18-19 from the center column; No. 20-21-22-7-8-9-10 from the right hand column. The lower arms are then swung around and the drills turned down for the bench holes, all holes being drilled without changing the set-up of the columns. All holes are started at 3 inches and bottomed at 2¼ inches, Rose and Cross bits on 1¼ and 1½ hexagon steel being used.

Drilling is started about 4 P. M. and the round is completed in one shift. Blasting is carried on from 4 A. M. to about 7, holes being shot by electricity; 700 to 800 lbs. of powder is used per day for both headings, side and bench holes are loaded with 10 to 12 lbs. and cut holes with 9 to 10 lbs. The short cut holes and the bench are shot first, the long

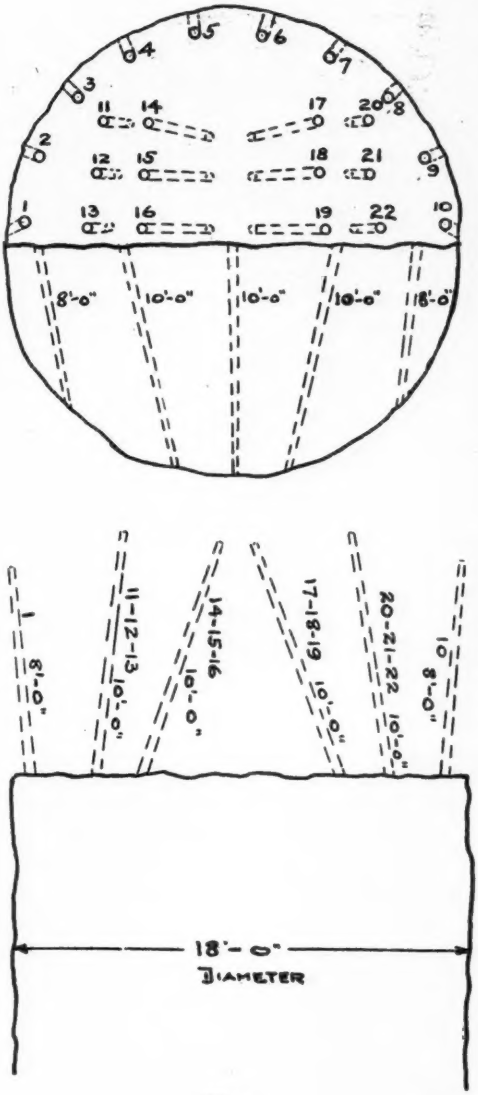

FIG. 1.

cut second and the back and side holes last. The heading has been advanced steadily at an average of 7½ ft. per day.

A saving is made in the high priced drill runners' time by having the mucking crew set up the drills, ready for the next round, as soon as they have cleared away the breast. This means that the drill runners can begin work without delay, everything being ready for them by 4 P. M.

In the north heading some soft material was encountered and temporary steel mine props

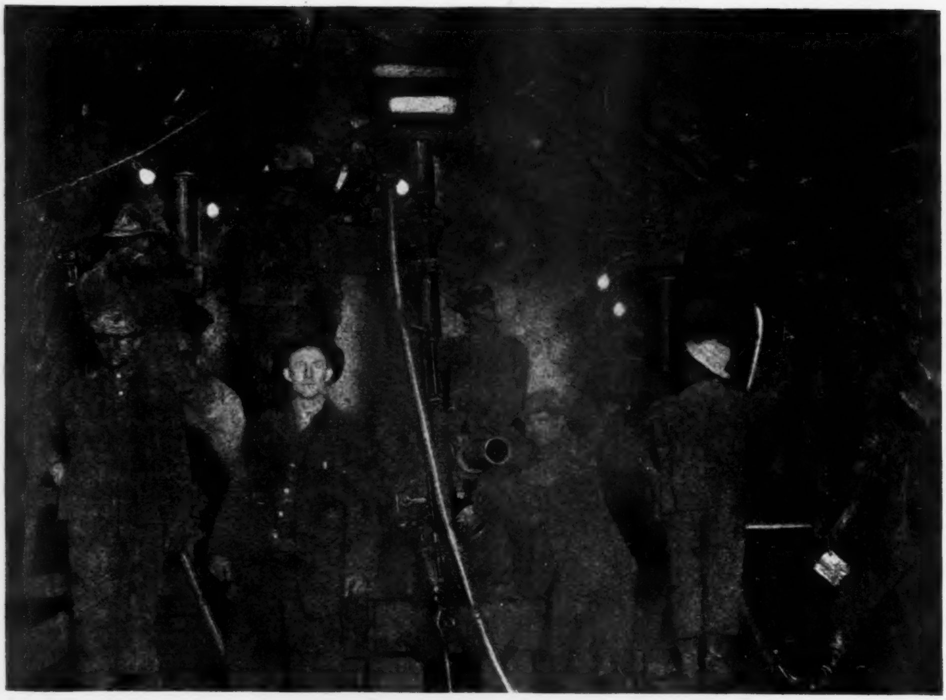

FIG. 2. WORK IN THE HEADING.

FIG. 3. BELT DRIVEN COMPRESSOR—WITHOUT THE BELT.

were resorted to, these had to be placed so close to the face that they suffered severely from the blast every time the face was shot, and considerable time was lost straightening the bent and twisted props before regular work could be resumed.

The drill crew, for each heading, consists of 6 drill runners, 6 helpers and a water boy.

MUCKING.

A double track is laid from the shaft to within a short distance of the breast, while a single overhead trolley wire supplies current for a small electric mine locomotive. From the end of the permanent track to the breast, rails are laid on one side and the flanges of the truck wheels run in the channel section, the locomotive taking its power through a length of wire connected at one end to the overhead system, the other end being wound and unwound on a winch attached to the locomotive.

As soon as the foul gases have been sufficiently dispersed, air being blown in from a fan through a conduit reaching nearly to the face, the mucking gang start work, clearing away the breast. An overhead system of planks is laid from the bench to the end of the car tracks, supported on bars set between the sides of the tunnel and of a sufficient height to allow the mine trucks to pass underneath. Two mine trucks are run as close to the breast as the muck will allow, part of the mucking gang work on the floor of the tunnel, shoveling into the nearest truck and working towards the breast, the rest work on top of the muck, shoveling into the nearest truck and working towards the breast, the rest work on top of the muck, shoveling into barrows on the overhead system and working away from the breast, the barrows, of which there are two kept going, are emptied into the farthest mine truck.

Owing to the large cross section of the tunnel, necessitating the removal of a correspondingly large amount of spoil each shift, mucking is practically carried on continuously.

EQUIPMENT.

In the several contracts of the New York section compressed air is supplied mostly by electrically driven compressors, either belted or direct connected. The compressors at this shaft are of the "Imperial" Type with an aggregate capacity sufficient to run 8 out of the 12 piston drills used, the work in the headings being arranged accordingly. They are "long belted" to GE motors of 100 and 200 H. P.

These particular machines have not had a cent of repairs on them since they were purchased by the Pittsburgh Contracting Co., two and one-half years ago. In some of the later installations greater economy has been gained by the use of direct connected electric driven air compressors, of these there are ten Ingersoll-Rand Class PE-2 and 3 Sullivan direct connected machines; using motors of the engine type as manufactured by the General Electric Co., Crocker Wheeler and Westinghouse Mfg. Co.

Though the first cost of direct connected units is necessarily higher, the saving realized, even in installations of a semi-permanent character such as these, is so marked, that first cost, so long as it is commercial, can be regarded as a minor consideration.

Of the Rock Drills used the "Sergeant" type seems to be the favorite, 3¼ and 3½ inch machines being most generally used.

One of the drills used in shaft No. 6 is a small light machine of a comparatively new design—called the "Improved Sergeant." It is a very hard, fast hitter and seems to easily hold its own against its larger contemporaries.

Trimming is mostly done with a "Bull Moose" or rotating "Jap" drill, or a Jackhamer, the automatic rotating features of these drills greatly facilitating the work.

Several Triplex pumps are used for unwatering the various shafts and in shaft No. 6 a small direct acting air operated pump was placed about half way to the heading. The pumps were not in operation during the writer's visit, very little water being present. Altogether the work is progressing very well, considering the size of the tunnel and the hardness of the rock. The methods might be said to be typical for the greater part of the Aqueduct, varying mostly in minor details. It is of course impossible to list all of the equipment used, since this is of such a varying character, though the two most important items entering into tunnel driving, the compressors and rock drills seem to be fairly well standardized.

A new heat indicator is a bright red paint which turns almost black before reaching the boiling point and resumes its normal color when it cools again.

The Mine Mule

By Berton Braley

He sees the pleasant daylight only once or twice a year,
    When they take him out to gambol on the grass;
But he cocks those funny eyes of his and waves a crazy ear,
    And you bet he's wise to all that comes to pass.
He is meaner than the skinner—and the skinner's awful mean—
    But he's stronger than the cable on the cage;
And of all the critters underground it's plainly to be seen
    That the mule's the boy who always earns his wage!

The skinner is a driver who swears a purple streak,
    But profanity is love talk to the mule;
He would kick the gentle miner to the middle of next week,
    But when the skinner beats him he is cool.
For the mule he loves the skinner, and the skinner loves him back,
    Though you sure would never know it by his talk;
And the mule he hauls a string of cars along the bumpy track
    And very, very seldom will he balk.

But if the mule gets sulky he can tangle up the mine,
    While the pit boss and the cager stand and swear;
And the cars are backed behind him in a long, unbroken line
    And the skinner hops around and tears his hair.
Yet when the mule is ready he will start to work again,
    And merrily he hauls the cars away;
For like that guy, Sir Galahad, he has the strength of ten
    When he really wants to bring it into play.

So, here's to Mr. Long Ears with the tassel on his tail,
    May he prosper like a dividend that's fat;
And when he's done with working and he hits the spirit trail,
    May he go where all the saintly mules are at!
Where there isn't any mining and there isn't any coal,
    And a skinner is a critter never met;
Where the only occupation is to bray with all his soul
    For the mule has earned his Heaven, you can bet!

—*Coal Age.*

COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC

Established 1896

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[In the March issue of COMPRESSED AIR MAGAZINE, page 6733, the first four lines at the top of the first column belong at the bottom of the second column.]

THE YOUNGER GENERATION OF ROCK DRILLS

One of the handiest additions to the rock drill complement in recent years, has been the perfected hand-hammer drill known in various mining sections by different terms of endearment, such as "Plugger Drill;" "Jap Drill;" "Jackhamer," etc.

It has come to be recognized as the "Handy Andy" of them all.

This little drill in addition to many well known applications, such as pop-shooting, plug and feather work in quarries, breaking up boulders and taking out ledges of rock in road construction, trimming walls and cutting hitches in mines and tunnels, as well as shaft sinking, etc., has recently been applied to the removal of old foundations of various descriptions in the building field as well as machinery foundations.

Every large industrial plant has at some time or other been confronted by the problem of growth necessitating building enlargements or the replacement of obsolete or inadequate machine tools by more modern equipment calling for new and heavier foundations and therefore the alteration or removal of the old.

Heretofore it has been the custom to remove these foundations (which in the majority of cases are of solid concrete) by hand; a slow, laborious and expensive process. Concrete itself, being composed of a number of constituents, presents great difficulties in drilling to the ordinary hand rotated machine drill, various experiments in the past having always resulted in a return to hand methods.

Quite recently the Philadelphia Electric Co., of Philadelphia, had in one of their local power stations a large machine foundation which they were obliged to remove in order to install a machine of another character from that previously occupying the space. This foundation was surrounded on all sides by expensive and delicate machines, necessitating a careful selection of the method and means for doing the work. A test was therefore made of several devices which could be applied, resulting in the adoption of an auto-

matically rotated "Plugger" or "Jackhamer" drill for this work.

There is a certain percentage of moisture present in concrete, which seems to cause the dust to pack and form a mud collar above the bit making it necessary, where hand rotated tools are employed, to withdraw the steel by means of a wrench, which operation is generally attended by considerable labor and difficulty; whereas with the automatically rotating type no difficulty is experienced from these mud collars.

A steel holding device attached to the tool made it possible to agitate the mud, further a throttle placed in the exhaust elbow made it possible to throttle the exhaust and force it through the hollow drill steel to the bottom of the drill hole, effectually removing the dust and mud. In a test run it was found that a progress of 24 inches could be made in 1 minute and 12 seconds as compared to 18 inches in 5½ minutes with the hand rotated type.

DEEP MINING

The Witwatersrand is now mining ore at a depth of over 5,000 ft. The South African Mining Journal says the probabilities are that in the not distant future Rand ore will be worked at a depth of a mile and a half and even more, there being no mechanical barriers to prevent it. For the present, however, the greatest depth to which man has penetrated on the Rand is 5,040 feet, which is the vertical depth at the bottom of the inclined portion in the Catlin shaft of the Jupiter Gold Mining Company. The depth of the vertical portion of this shaft is 4,243 feet. The second deepest shaft on the Witwatersrand is the Turf Mines shaft of the Village Deep Company, which has been sunk to 4,144 feet. The vertical depth at the bottom of the inclined portion of this shaft is 4,184 feet. It can safely be asserted that no other metalliferous formation in the world has been found to extend over such a large area and to such a great depth as the Main Reef series, and the statistics, considering the small and uniform increase in temperature noted in these deep workings, must make one very hopeful as to the possibilities of mining at a profit 8,000 feet below the surface. Two other gold mines have probed the earth to a depth as great if not greater than the Rand properties. These are the St. John del Rey, in Brazil, and the New Chum Railway Mine, in Victoria. The greatest depths of all at which metalliferous mining is being carried on at the present time are in the Michigan copper belt, where they work at a vertical depth of between 5,000 and 6,000 feet. The deepest collieries are in Belgium and Germany, where, we believe, colliers are at work at depths of a mile and a quarter from the surface.

NECESSITY OF TRAINING FOR MINE RESCUERS

There is some difference of opinion among persons who have worn breathing apparatus in actual mine-rescue work as to the length of time a man should be required to receive training with the apparatus before he is considered as qualified to engage in mine-rescue or recovery work. All, however, admit that it is necessary for a man to take regular training at stated intervals in order to keep in proper condition for wearing the apparatus in cases of emergency. Whether the duration of the intervals be two weeks or three months, some system of regular practice should be adopted. The Bureau of Mines requires each of the miners it employs at its mine-safety cars and stations to take two hours' practice in vitiated air once each week. At mining camps or mines where rescue stations are established, the regular mine-rescue corps should be required, after completing their preliminary training, to undergo practice at frequent intervals. In localities where rescue stations and apparatus are not available, it is, of course, impracticable for persons who have received preparatory training to keep up regular practice. Such persons, however, are very valuble in time of a disastrous explosion, since their training and instruction in the use of the apparatus enables them to be of great assistance to a crew of rescuers who may arrive with a breathing apparatus.

CONFIDENTIAL EMPLOYMENT DEPARTMENT

10. A good drill repair man wanted on a large railroad contract in the Middle States.

11. Air compressor engineer now employed. Takes charge of all repairs, steam or electric drive.

12. Compressor runner and repairer, Kentucky or Tennessee. Ten years' experience.

13. Educated man of large experience as master mechanic, chief engineer or electrician. At present holds position of chief operating engineer and electrician of large railroad shops. Prefers position east of Mississippi.

14. Has had experience in running air compressors. Would like position as compressor engineer.

15. Has been assistant master mechanic in large rubber factory and later master mechanic of granite quarry. Familiar with steam engines, electric motors, air compressors and rock drills. Live young man.

16. Was chief engineer of large marble quarry 10 years. At present compressor engineer on tunnel contract. Would like permanent position as chief engineer.

17. Has been engineer for building contractors. Familiar with engines, hoists and compressors.

THE UNSINKABLE SHIP

The new battleship Pennsylvania and its two immediate predecessors, now under construction, the Nevada and Oklahoma, of the United States Navy, are to be equipped with a novel installation for localizing and minimizing the effects of under-water injuries. The scheme broadly means nothing short of turning all of these water-tight divisions into so many separate caissons, from which the water can be expelled or held within limits through the medium of compressed air.

It has commonly been supposed that the system was in a sense the outcome of the foundering of the Titanic, but as a matter of fact the general plan antedates that catastrophe by many months—in short, is the direct consequence of the last efforts made to salve the United S. S. cruiser Yankee in 1908. It is another case of where unsuccess has taught a profitable lesson.

The United S. S. Yankee hit the rocks of "Hen and Chickens Reef" outside of Newport and was stranded in a particularly awkward manner. Three experienced salvage companies essayed to refloat the cruiser for the Government, but after weeks of fruitless efforts they abandoned the undertaking as hopeless. But by means of compressed air the vessel was given enough buoyancy aft to permit of her being dragged from her lodgment upon the reef. Unfortunately, she was run into and sunk while being towed to harbor. Again, her salvors, Messrs. W. W. Wotherspoon and R. O. King, undismayed by that casualty, struck out upon still more novel lines. The 'tween-deck spaces were divided into air chambers and successively sealed, and air locks were formed by utilizing existing ammunition hoists. When everything was ready compressed air was pumped into these improvised caissons and the vessel started to rise—in fact, actually reached the surface; but one of the temporary air locks proved unequal to the pressure, burst, and the ship filled and sank again. That accident proved extremely instructive to Mr. Wotherspoon, and also suggested to him how it would be possible to make any fighting ship virtually not only her own self-contained salvage plant but practically unsinkable.

As is well known, every man-of-war is subdivided from a point above the water line to her keelsons into many hundred separate water-tight compartments, for the logical purpose of confining injury should the outer and inner bottoms be pierced. All of these divisions are connected to an extensive drainage system, and ordinarily powerful pumps are counted upon to overcome leakage or to fight on more or less equal terms against the invading sea. If a compartment filled, notwithstanding the pumps, and the invasion stopped there, then the consequences might not be very serious. But, unfortunately, the pressure upon bulkheads and decks is often too great; hence they yield, and the neighboring compartments are likewise inundated. The pumps then have far more than they can combat and the ship is either heeled over so that she is put *hors de combat* or she goes to the bottom. This gradual giving way of the structure may occupy a period of many hours, and yet the ship is certainly doomed because of the one-sided stresses upon decks and bulkheads.

Mr. Wotherspoon actually subdivides a ship equipped with his installation into successive strata or layers of compressed air zones, and he distributes these as the emergency arises so as to meet the requirements of each exigency. In other words, the pressure of the air on the opposing sides of a deck or bulkhead is such that the resultant difference on the side of greater pressure is a number of pounds less per square inch than would be the case if the compartment were filled with water and flanked only by normal atmospheric

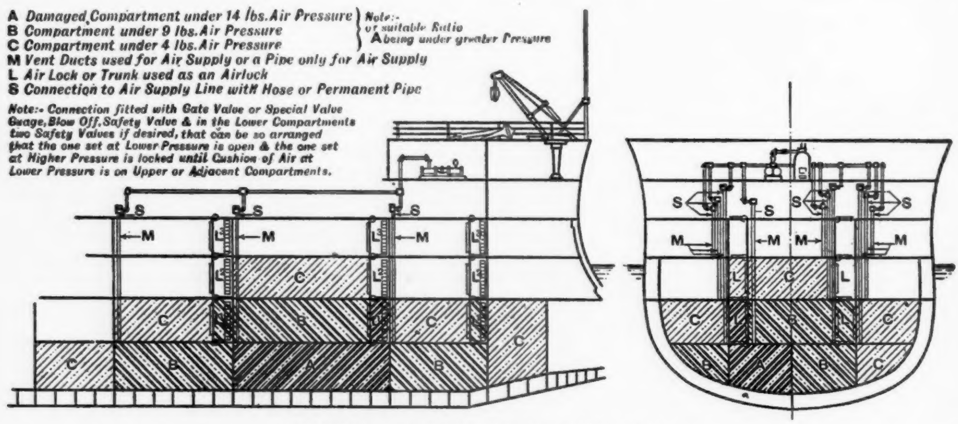
conditions. In this manner the structure of the damaged space is supported by the enveloping body of the ship throughout a pretty wide area, and this effectually guards against the yielding of the walls directly encompassing the damaged region.

Offhand the critcism first offered to the scheme by the naval authorities at Washington was that the equipment would involve too much weight would be very costly to put in place and would substantially mean the clearing out of most of the compartments for that purpose. This was the reply to the inventor's proposal that some one of the larger vessels already in service should be fitted experimentally. Mr. Wotherspoon met all of these objections and the armoured cruiser North Carolina was chosen for the test installation. It was elected to connect the apparatus with something like 800 of the ship's water-tight compartments, and the naval constructors were decidedly miserly in the total weight allowance which they granted the pneumatic engineer.

As is common knowledge among naval men, the underwater compartments of all men-of-war are forcibly ventilated to guard against the accumulation of gases and foul air. This is effected by a double system of piping, one carrying fresh air into the compartment and the other supplying an outlet for the tainted exhaust. Running down below the water line as it does all of this piping is subjected to pressure tests and must be equal to any tax which may be placed upon it by water pressure due to flooding, and therefore these conduits already in place stood ready to serve another purpose. By these channels Mr. Wotherspoon can lead compressed air to any of the compartments and the only additional apparatus needed for this work is a flexible attachment for effecting connnection with a source of air supply. Originally this was the air compressors but it is now intended to have air stored in reserve in sufficient quantity to help toward the immediate checking of any dangerous admission of water.

A supplemental feature is that of air locks extending from the uppermost water-tight deck down to the lowest water-tight spaces, and these air locks, by means of suitable vertical doors—not the top doors—on each deck make these convenient passageways between decks for all ordinary traffic.

The athwartship section given herewith shows the general arrangement of the system upon one of the United States naval vessels. Compartment A is the damaged one, and theoretically is under an air pressure of 14 lb. to the square inch. The contiguous compartments B B B are filled with air at a pressure of 9 lb. per square inch and this leaves a resultant bursting pressure upon the walls of compartment A of only 5 lb. per square inch. The outlying spaces C C C are charged with air at a pressure of 4 lb. per square inch and again this leaves a resultant bursting pressure of 5 lb. within compartments B B B. Therefore instead of the walls of the damaged compartment A having to withstand the entire stresses due to the confined air at 14 lb. pressure per square inch the flanking



SECTION OF BATTLESHIP PENNSYLVANIA.

and superposed enveloping ship fabric is bearing its part progressively. The longitudinal section gives another idea of the distribution of the various air strata or zones and the cushioning effect of this arrangement is obvious.

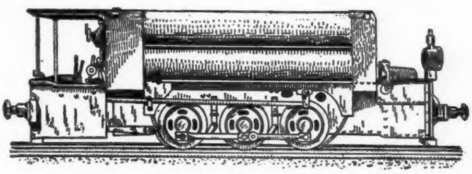
Despite the weight limit placed upon Mr. Wotherspoon, he effected his installation with a very material saving. Indeed, there was very little needed for the equipment, save some special valves, which was not already on board the North Carolina, and the ship's artisans' did most of the work of installation.

According to the building specifications of every fighting craft all of the water-tight compartments are required to be tested some time during the ship's construction. This test for water-tightness when carried out does not involve pressure testing to any pronounced extent and the spaces are seldom, if ever, filled as they would in all probability be in case of flooding due to damage. But, apart from this, the very complexity of the craft requires the placing of many mechanisms before decks are built over and other work finished. Some of this plant is of a nature which prohibits the subsequent testing of the compartments by water, and water-tightness is taken for granted and assumed on the score that workmanship and paint have made them so. These have proved a flimsy reliance, and in the case of the North Carolina, it was found that more than one compartment was leaky when the compressed air was used. Not only was this so, but a good many water-tight doors theoretically perfect proved to be anything but tight. In most cases this was found to be due to worn gaskets and loosened fittings, but these potential leaks would have escaped notice but for the telltale hissing of the liberated air. Thus, apart from its virtue in case of injury to the bottom platings, the system as installed upon the North Carolina showed how valuable it could be in checking the water-tightness of the craft within its own body structure. The secondary usefulness might easily resolve itself into one of prime importance under some conditions.

Mr. Wotherspoon has made his system alike valuable for the smothering of fires as well as for the arresting of leakage. Instead of turning compressed air into a compartment he chokes out a conflagration by using the same conduits to carry a gas which will not support combustion into the endangered division.

A third advantage of this dual fire-and-water protecting system is the peculiar facility which it offers for making temporary repairs. By means of the air locks it is possible for the men to enter an affected compartment and to overhaul a leaky valve and replace it without any inconvenience. Again, should the injury involve a rupture of the ship's inner or outer plating, that, too, can be temporarily stopped or plugged or otherwise sealed as the occasion may best afford. The men would simply be working in the structural double of a caisson.

While Mr. Wotherspoon has confined the application of his system so far to the heavy battle craft of the United States navy, there is no reason why the same installation should not be adapted to the higher classes of merchant craft as well.—*The Engineer, London.*



TESTS OF TUNNEL COMPRESSED AIR LOCOMOTIVES

For the construction of the Mont d'Or tunnel the A. Borsig works, Berlin-Tegel, Germany, have delivered two locomotives of different types; one a three-axle of 11 tons weight and the other a four axle of 31 tons, both with compound air cylinders and double preheating of the air.

The air is carried at high pressure in two long cylindrical tanks, and after coming from the pressure reducing valve it passes through a special set of heater pipes before entering the high pressure cylinder and doing that portion of its work. In passing from the high pressure to the low pressure cylinder it is led through a second set of similar heating pipes. The cut shows the general features of the design of these machines.

The furnace for heating the pipes is on the locomotive frame, a small stack being provided in the front part of the locomotive to take care of the gases of combustion. Coal and charcoal are used for fuel in order to obtain a practically smokeless combustion. The preheating is such as to raise the temperature of the air in both cylinders to about 180 deg. cent. (356 deg. fahr.) With a grade of 0.13

	Small	Large
Number of cars	9	15
Kind of cars	box cars	15 tip wagons, 1 box car
Light weight	2.2 tons 4840 lb.	2.8 or 2.2 ton 6160 or 4840 lb.
Gross weight	8.4 tons 18480 lb.	11.6 or 8.4 ton 25520 or 18480
Duration of run, min	10.5	20.5
Length of run, m/yards	1000/1093	1870/2043
Speed m. per sec./ft. per sec	1.59/4.77	1.52/4.65
Initial pressure in the air tanks, atmospheres	84	68
Final pressure in the air tanks, atmospheres	29	23
Number of readings taken	10	19
Grand average pressure in the working flask, atmospheres	15	15 5
Temperature of the entering air at beginning of run:		
high-pressure cylinder, cent./fahr	...	80/176
low-pressure cylinder, cent./fahr	....	80/176
Temperature of entering air at end of run:		
high-pressure cylinder, cent./fahr	80/176	64/147.2
low-pressure cylinder, cent./fahr	45/113	58/136.4

TABLE 1.

per cent., the larger locomotives can haul up to 180 tons, and the smaller up to 55 tons gross (in all cases a metric ton of 2,200 lb. is meant).

An account of a series of tests of these locomotives has been published in *Glückauf*. The data are interesting particularly on account of the scarcity of tests of tunnel locomotives under operative conditions, tunnel construction being usually done under conditions and guarantees as to the time of delivery which permit no interruptions for the purposes of tests. During the tests the locomotive was in front of the train when it moved tunnelwards, and behind when it moved out of the tunnel. In normal operation the opposite arrangement is of course used, since with a grade of 0.13 per cent. and the heavy train used, a break of a coupling would cause great danger unless the locomotive was always be-

	European Units								
	Length of Run, m.	Gross Load, t.	Output, tkm.	Useful Load, t.	Tractive Effort Locomotive and Train, Kg.	Output I. H. P., Hr.	Consumption of Air: Total Cbm.	Consumption of Air: Per Tkm, Cbm.	Consumption of Air: Per H.p-Hr., Cbm.
Small Locomotive:									
Upgrade	1000	76.35	76.35	55.80	1627	6026	123.75	1.621	24.317
Downgrade	1000	76.35	76.35	55.80	60	0/222	4.50	0.059	24.324
	American Units								
	Miles	Tons Am.	Ton-Miles	Tons Am.	Lb.		Cu. Ft.	Per Ton-Mile, Cu. Ft.	Per H.p. Am.-Hr., Cu. Ft.
Upgrade	0.621	69.4	43.09	50.7	3579		4332	32	840
Downgrade	0.621	69.4	43.09	50.7	132		158	1.22	840
	European Units								
Large Locomotive:									
Upgrade	1870	183 20	324.58	138.2	3645	25245	459 00	1.34	22 611
Downgrade	1770	183.20	324.26	138.2	100	0.656	13.26	0.04	23 806
	American Units								
Upgrade	1.16	166.3	192.90	125.8	8019		16065	26.3	783
Downgrade	1.09	166.3	181.267	114.2	220		455	0.79	825

TABLE 11.

low grade from the train. To take care of that during the tests, there was always a second locomotive at some distance on the other side of the train. Both locomotives were tested just as they were, without previous overhauling or even cleaning. Previous to the tests they had been over a year in actual service on the construction. The air capacity of the tanks could be established only by calculation, and was found to be for the small locomotive 78.75 cu. ft., and for the large locomotive 357 cu. ft. The comparatively low temperature of preheating indicates that the smoke stack was choked up, the temperatures obtained at the delivery tests having been considerably higher. The author states, however, that temperatures of 45 to 54 deg. cent. (113 to 129.2 deg. fahr.) in front of the low-pressure cylinder are about as high as one can go economically with this kind of locomotive where strong preheating permits the expansion of the air to be driven very high in the cylinder. The data of the tests are given in Tables 1 and 2.

BUREAU OF MINES BILL SIGNED

President Taft on February 25 signed a bill which defines more clearly the functions and broadens the scope of the Federal Bureau of Mines. This act is the first general recognition by the Federal Government of all branches of the mining industry. Representative Foster, chairman of the House Committee on Mines and Mining, speaking on the subject, said: "The Bureau of Mines retains its original name under the law, but it becomes a bureau of mining, metallurgy, and mineral technology, and this represents the wider scope of the new organization." The purposes are better to safeguard the lives of the men engaged in hazardous occupations, to prevent unnecessary waste of natural resources and to aid in the general upbuilding of mining.

OWNERS OF MINING STOCK MISSING

Four men who dropped from sight in the Spokane country several years ago are being sought by directors of the Tamarack & Chesapeake Mining Company. The four men have an aggregate of 7,250 shares of stock in the mine, which they secured when the property was but a prospect whose stock went for from 3 to 5 cents a share. To-day it is bringing $1.55 a share, making their holdings worth $11,347.50. Patrick Turley, H. L. Stoddard and A. L. Humphrey were miners in the employ of the company and took shares for their wages on a basis of 5 cents per share. In this way Turley secured 4,250 shares, now worth $6,587.50, and Stoddard and Humphrey took 1,000 shares apiece, making the value of the holdings of each $1,550. F. E. Hemenway, the fourth man, bought 1,000 shares at 3 cents while employed as a cabdriver in Spokane.

ENTERING A COAL MINE AFTER AN EXPLOSION

Great precaution is necessary in entering a mine after an explosion if the lives of rescuers are not to be imperilled. First of all, the ventilation has to be restored. If the fan or fan-house is wrecked it has to be repaired in the quickest possible way. Enter the mine with the intake of air, and repair the air course enough to restore ventilation. A safety-lamp ought always to be used in advance work to guard against after-damp explosions. Where rescue apparatus is used the difficulties for rescue work are more quickly overcome. In igniting a small body of fire-damp the biggest proportion of after-damp is carbon dioxide; the same result will be found in a pure fire-damp explosion.

NOTES

On page 6718 of the February issue of Compressed Air Magazine there appeared an illustrated article describing the operating of water gate valves by means of compressed air motors. This was properly credited by us to *Insurance Engineering*, from which it was taken by us. It originally appeared, however, in *Ideal Power*, and we are glad to thus call attention to the fact.

A 15,000-hp Pelton wheel, believed to be the largest unit of its type in Europe, is being installed in the Löntsch hydro-electric power station on the Klönthalersee near Glarus. The present installation consists of six 6,500-hp Pelton wheels, directly connected to their respective generators. The new unit will increase the capacity of the station from 39,000 to 54,000 hp, making it the largest in Switzerland.

The State Mine Inspector of Montana reports that the development work in Butte during the past year was 57 per cent. greater than any year in its history. The Anaconda company alone did 30 miles of underground work, and the other companies, even the smallest, did their share.

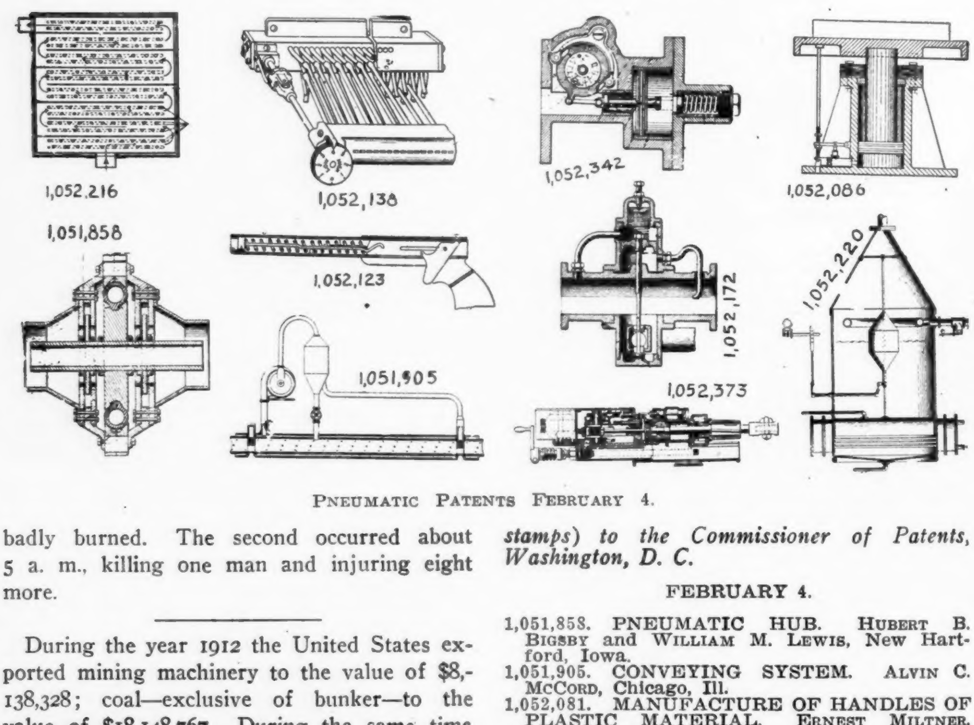
Two tunnel explosions occurred at Chicago, on January 14 and 15, in a branch water-supply tunnel, at about 72d St. and Cottage Grove Ave. Pockets of natural gas are considered as the cause of both accidents. The first occurred about 11.30 p. m., and three men were badly burned. The second occurred about 5 a. m., killing one man and injuring eight more.

During the year 1912 the United States exported mining machinery to the value of $8,138,328; coal—exclusive of bunker—to the value of $18,148,767. During the same time there were imported 1,608,350 tons of bituminous coal, and coal-tar colors and dyes to the value of $7,316,697. The balance was on our side, but it took substantially all the mining machinery we exported to pay for the coal-tar products, which we should have made in large part ourselves.

The Ferrocarril de los Altos, in construction between San Felipe (terminus of a branch of the Guatemala Central Railroad, at 2,056 feet elevation) and Quezaltenango, second city in size of the Republic, at 7,800 feet elevation, has now progressed to the point of having 8 miles of roadbed graded and ready for laying rails and putting in bridges. This railroad is being built under the direct supervision of the Government of Guatemala. On account of the ascent to be overcome, about 40 miles of track will be necessary to make the distance of about 30 miles between the two cities named.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sendingn five cents (not stamps) to the Commissioner of Patents, Washington, D. C.



PNEUMATIC PATENTS FEBRUARY 4.

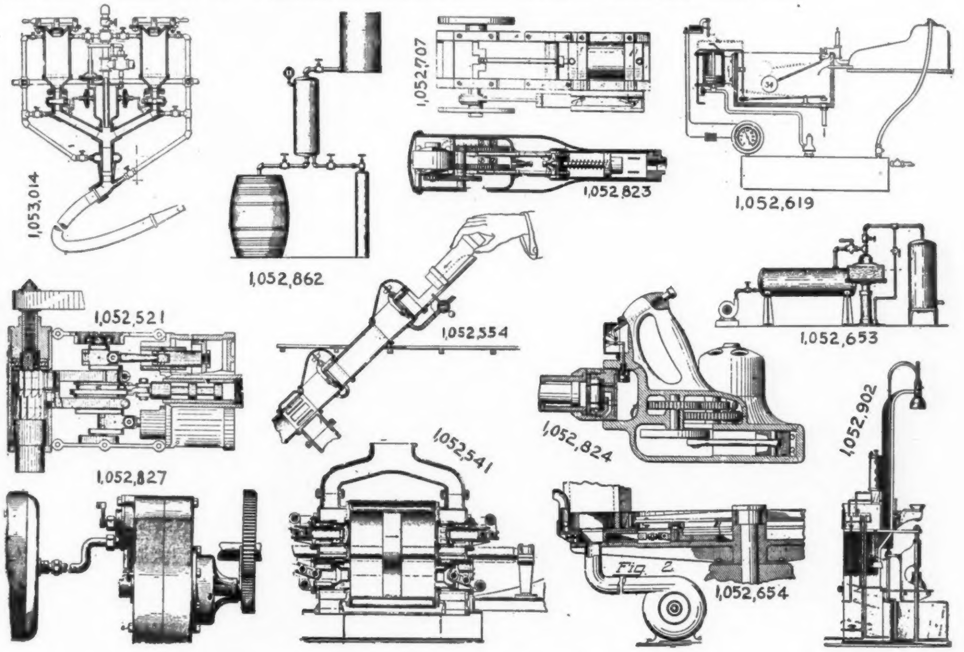
FEBRUARY 4.

1,051,858. PNEUMATIC HUB. HUBERT B. BIGSBY and WILLIAM M. LEWIS, New Hartford, Iowa.
1,051,905. CONVEYING SYSTEM. ALVIN C. MCCORD, Chicago, Ill.
1,052,081. MANUFACTURE OF HANDLES OF PLASTIC MATERIAL. ERNEST MILTNER, Newark, N. J.
1,052,086. JOLT RAMMING APPARATUS. EDGAR H. MUMFORD, Plainfield, N. J.
1,052,123. AIR-GUN. BURTON B. BENNETT, Plymouth, Mich.
1,052,138. TRANSPOSER FOR PNEUMATIC MUSICAL INSTRUMENTS. JOHN J. DOSSERT, Syracuse, N. Y.
1,052,172. AUTOMATIC RELIEF-VALVE FOR FLUID-IMPELLING APPARATUS. AUGUSTE CAMILLE EDMOND RATEAU, Paris, France.
1,052,216. APPARATUS FOR ABSORBING CARBONIC ACID FROM AIR. CHARLES CHRISTIANSEN, Gelsenkirchen, Germany.
1,052,220. PROCESS AND APPARATUS FOR TREATING LIQUIDS. EUGENE W. DEMING, New York, N. Y.
1,052,342. TRIPLE VALVE. EPHRAIM K. HUTCHINSON, Ely, Nev.
1,052,373. ROCK-DRILL. ALEXANDER PALMROS, Syracuse, N. Y.

FEBRUARY 11.

1,052,521. END-SPINDLE AIR-DRILL. ARTHUR SCOTT, Cleveland, Ohio.
1,052,541. GAS COMPRESSOR AND PUMP. ARTHUR J. WEST, Bethlehem, Pa.
1,052,554. VALVE FOR PNEUMATIC-DESPATCH-TUBE APPARATUS. WILLIAM H. AMES, Easton, Mass.
1,052,619. AUTOMATIC CONTROL FOR AIR-COMPRESSORS. WILLIAM L. PICKETT, Bridgeport, Conn.
1,052,653. PNEUMATIC MEASURING - MACHINE. JOSEPH P. CROWLEY, Toledo, Ohio.
1,052,654. MEASURING-MACHINE FOR TOBACCO, &c. JOSEPH P. CROWLEY, Toledo, Ohio.
1,052,707. AIR-ENGINE. FRIEND A. ALLEN, Granger, Mo.
1,052,823. POWER-ACTUATED HAND-TOOL. ALBERT M. IRVINE, Philadelphia, Pa.
1,052,824. POWER-ACTUATED HAND-TOOL. ALBERT M. IRVINE, Philadelphia, Pa.
1,052,862. PROCESS OF PICKLING MEATS.

1,053,383. PERCUSSIVE TOOL. CHARLES H. HAESELER, Philadelphia, Pa.
1,053,412. PNEUMATIC CONVEYER. GUIDO E. LOB, Chicago, Ill.
1,053,427. ACETYLENE - GAS APPARATUS. ANDREW MOSER, Hickman, Nebr.
1,053,452. APPARATUS FOR TRANSPORTING LIQUIDS OR GASES. EDWARD C. STOVER, Trenton, N. J.
1,053,581. ELECTRIC PNEUMATIC SWITCH. JOHN DESMOND, Chicago, Ill.
1,053,666. AUTOMATIC EQUALIZATING - VALVE. ARMSTRONG M. STARKEY, McKinney, Tex.
1,053,696. TRIPLE VALVE FOR AIR-BRAKE SYSTEMS. CHARLES H. ATKINS, Springfield, Mass.
1,053,793. GAS AND AIR MIXER. ARTHUR DOCKING, Nottingham, England.
1,053,802. HUMIDIFIER. WILLIAM H. FLETCHER, Paterson, N. J.
1,053,904. AIR - COMPRESSOR GOVERNOR. RUDOLPH CONRADER, Erie, Pa.



PNEUMATIC PATENTS FEBRUARY 11.

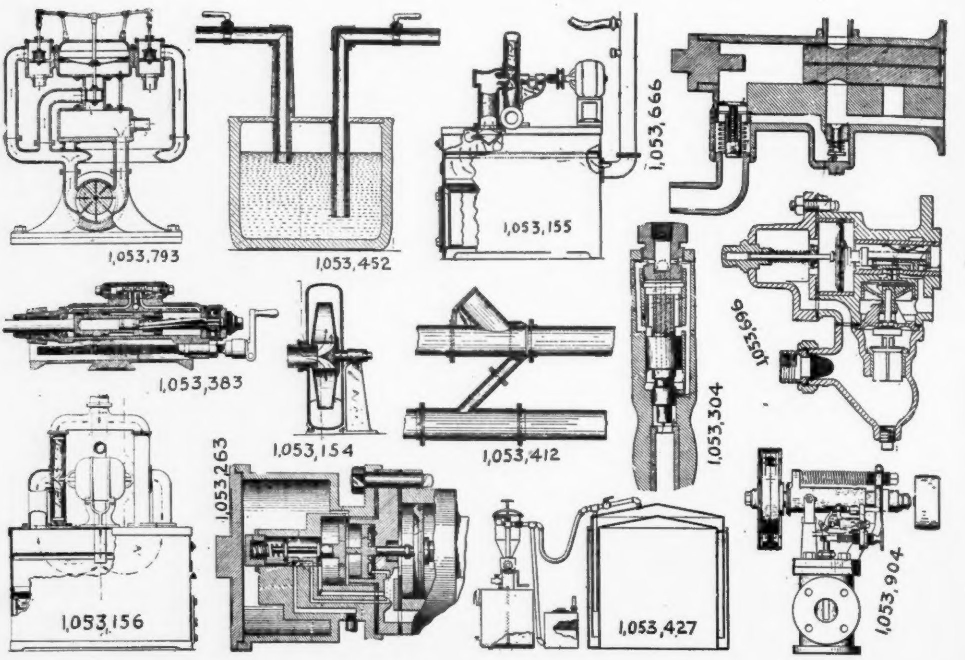
CHARLES B. TRESCOTT, Indianapolis, Ind.
1,052,902. GLASS-BLOWING MACHINE. VERNON M. DORSEY, Laurel Grove, Md.
1,053,014. PNEUMATIC PLASTERING - MACHINE. PETER L. CRON, Elizabeth, N. J.
1,053,093. PRESSURE - ACTUATED TOOL. GEORGE H. GILMAN, Claremont, N. H.

FEBRUARY 18.

1,053,154. CENTRIFUGAL FAN. CHARLES G. CAMPBELL and MONROE BENBROOK, Milwaukee, Wis.
1,053,155. VACUUM - CREATING APPARATUS. CHARLES G. CAMPBELL and MONROE BENBROOK, Milwaukee, Wis.
1,053,156. AIR-CIRCULATING SYSTEM FOR VACUUM-PRODUCERS. CHARLES G. CAMPBELL and MONROE BENBROOK, Milwaukee, Wis.
1,053,263. AUTOMATIC FLUID - BRAKE. LOUIS H. ALBERS, Albany, N. Y.
1,053,246. LOAD-BRAKE APPARATUS. WALTER V. TURNER, Edgewood, Pa.
1,053,304. PNEUMATIC TOOL. HENRY E. LE GENDRE, Creskill, N. J.

FEBRUARY 25.

1,053,968. BLOWPIPE. LEON L. BOWER, Philadelphia, Pa.
1,053,991. COMBINED MOTOR AND AIR-PUMP. JOHN CHARLES HENDERSON, San Francisco, Cal.
1,054,056. MOISTURE-EXTRACTING APPARATUS. JOHN S. THURMAN and LYNNEAUS I. LOCKWOOD, St. Louis, Mo.
1,054,060. SOLDERING APPARATUS. WALTER ULBRICH, Leipzig, Germany.
1,054,080. METHOD OF COMBINING AIR AND GAS AND UTILIZING THE SAME IN AN INTERNAL COMBUSTION ENGINE. GUSTAV A. BACHMANN, Baltimore, Md.
1,054,211. AIR-COMPRESSOR. JUSTUS R. KINNEY, Dorchester, Mass.
1,054,343. PNEUMATIC TOOL. CHARLES A. FAESSLER, BUFFALO, N. Y.
1,054,417. FLUID-PRESSURE CONTROL OF TRANSOMS AND WINDOWS. JOB HUTCHINSON, New York, N. Y.



PNEUMATIC PATENTS FEBRUARY 25.

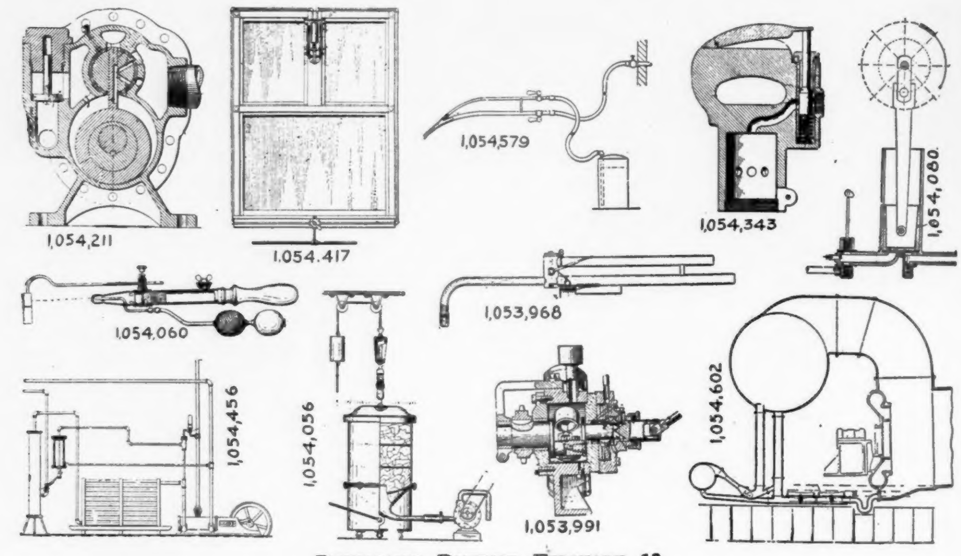
1,054,456. SAFETY ATTACHMENT FOR COMPRESSION REFRIGERATING APPARATUS. FRITZ A. SCHNEIDER, New York, N. Y.

1,054,579. CLEANING DEVICE. PATRICK ANDREW MAHON, New York, N. Y.

1,054,589. DEVICE FOR THE PRODUCTION OF PURE AIR. HUGO MESTERN, Berlin, Germany.

1,054,602. CONDENSING APPARATUS. CHARLES ALGERNON PARSONS, Newcastle-upon-Tyne, and STANLEY SMITH COOK, Wallsend, England.

1,054,650. PROCESS OF AND APPARATUS FOR MANUFACTURING DRIED FOOD PRODUCTS. MAURICE VOUGA, Neuchatel, Switzerland.



PNEUMATIC PATENTS FEBRUARY 18.